REPORT OF THE PROCEEDINGS

OF THE

Fortieth Annual Convention

OF THE

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

(INCORPORATED)

HELD AT

ATLANTIC CITY, N. J.,

June 12, 13 and 14, 1907.

CHICAGO:
THE HENRY O. SHEPARD COMPANY
120-130 SHERMAN STREET.
1907.

OFFICERS FOR 1907-1908.

ELECTED AT CLOSE OF CONVENTION OF 1907.

PRESIDENT.

WM. McINTOSH, Central Railroad of New Jersey, Jersey City, N. J.

FIRST VICE-PRESIDENT.

H. H. VAUGHAN, Canadian Pacific Railway, Montreal, Canada.

SECOND VICE-PRESIDENT.

G. W. WILDIN, New York, New Haven & Hartford Railroad, New Haven, Conn.

THIRD VICE-PRESIDENT.

F. H. CLARK, Chicago, Burlington & Quincy Railroad, Chicago, Ill.

TREASURER.

ANGUS SINCLAIR, New York City.

EXECUTIVE MEMBERS.

*A. E. MITCHELL, New York, New Haven & Hartford Railroad, New Haven, Conn.
*C. E. FULLER, Chicago & Alton Railroad, Bloomington, Ill.
*T. H. CURTIS, Louisville & Nashville Railroad, Louisville, Ky.
°C. A. SELEY, Chicago, Rock Island & Pacific Railway, Chicago, Ill.
°JOHN HOWARD, Boston & Albany Railroad, Boston, Mass.
°F. M. WHYTE, New York Central Lines, New York City.

SECRETARY.

JOS. W. TAYLOR, 390 Old Colony Building, Chicago, Ill.

* Term expires June, 1908.
° Term expires June, 1909.

COMMITTEES SELECTED FOR THE 1908 CONVENTION.

1.— *Mechanical Stokers:*

WM. GARSTANG, Chairman,
J. F. WALSH,
GEO. S. HODGINS,
D. F. CRAWFORD,
L. R. JOHNSON.

2.—*Blanks for Reporting Work on Engines Undergoing Repairs:*

T. H. CURTIS, Chairman,
E. W. PRATT,
C. E. CHAMBERS,
T. F. BARTON,
HENRY BARTLETT.

3.— *The Proper Amount to Which the Gauge of Track Should Be Widened on Curves of Different Radii to Secure the Best Results with Engines Having Different Lengths of Rigid Wheel Base:*

F. M. WHYTE, Chairman,
W. H. LEWIS,
F. C. CLEAVER.

4.— *The Apprenticeship System:*

G. M. BASFORD, Chairman,
C. W. CROSS,
W. D. ROBB,
A. W. GIBBS,
B. P. FLORY,
JOHN TONGE.

5.— Superheating:

H. H. VAUGHAN, Chairman,
LE GRAND PARISH,
R. D. HAWKINS.

6.— Best System of Washing-out and Refilling Locomotive Boilers:

H. T. BENTLEY, Chairman,
S. K. DICKERSON,
M. E. WELLS,
L. H. TURNER,
H. E. PASSMORE.

7.— Castellated Nuts:

R. B. KENDIG, Chairman,
J. F. DE VOY,
G. S. EDMONDS,
J. N. MOWERY,
JOHN PLAYER.

8.— Mallet Compounds:

J. E. MUHLFELD, Chairman,
G. H. EMERSON,
F. H. CLARK,
T. RUMNEY,
C. J. MELLIN.

9.— Balanced Compounds:

E. D. NELSON, Chairman,
JOHN HOWARD,
A. LOVELL,
J. F. GRAHAM,
W. L. AUSTIN.

10.—Sizes and Capacity of Safety Valves for Use on Locomotive Boilers:

F. M. GILBERT, Chairman,
H. D. TAYLOR,
JAS. MILLIKEN,
J. H. MANNING,
G. W. WILDIN.

11.—Revision of Standards and Recommendations:

W. H. V. ROSING, Chairman,
T. W. DEMAREST,
C. B. YOUNG.

12.—Subjects:

C. A. SELEY, Chairman,
L. R. POMEROY,
D. F. CRAWFORD.

INDIVIDUAL PAPERS.

1.—Is It Desirable to Have Uniform Specifications and Drawings of Locomotives of the Most Common Types and Sizes?

MR. G. M. BASFORD.

2.—Design and Strength of Crank Axles for Balanced Compound Locomotives:

MR. LAWFORD H. FRY.

3.—The Training of Technical Men:

PROF. A. W. SMITH, Cornell University.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this Association shall be the "American Railway Master Mechanics' Association."

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this Association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the Association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them:

(1) Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock.

(2) General foremen, if their names are presented by their superior officers.

(3) Two representatives from each locomotive and car building works.

(4) One representative member may be appointed by any railroad company to represent its interests in the Association. Such appointment shall be in writing and shall emanate from the President, General Manager or General Superintendent. Such member shall have all the privileges of an active member, including one vote on all questions, and, in addition thereto, shall, on all measures pertaining to the determination of what tests shall be conducted by the Association or the expenditure of money for conducting same, have one additional vote for each full one hundred engines which are in actual operation or in process of purchase by the road or system which he represents. Such membership shall continue until notice is given the Association of his withdrawal or the appointment of his successor.

SEC. 2. Civil and mechanical engineers, or other persons having such

a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the Association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate, and report to the Executive Committee of the Association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to letter ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. (1) All members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

(2) A representative member shall pay in addition to his personal dues as above, an amount for each additional vote to which he is entitled, as shall be determined each year by the Executive Committee, prorated upon the cost of conducting such tests as may be determined upon at each convention, provided that no such assessment shall exceed $5 per vote per year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this Association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of the Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the Association, active or associate, who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected honorary members. The nominations must be made by the Executive Committee. The dues of the honorary members shall be remitted, and they shall have all the privileges of active members except that of voting.

SEC. 6. Any member who, during the meetings of the Association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the Association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the Association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, a Secretary, and six Executive members, the six Executive members with the President, Vice-Presidents and Treasurer shall constitute the Executive Committee, and they, with the exception of the Secretary, shall constitute the Executive Committee of the Association.

ARTICLE V.

DUTIES OF OFFICERS.

SECTION 1. It shall be the duty of the President to preside at all the meetings of the Association, appoint all committees — designating the chairman — except as hereinafter provided, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore.*

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the Association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the Association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SECTION 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the Association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to an

amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the Association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report.

SEC. 3. Five members of the Executive Committee shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the annual convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually, intimating the date and place when and where candidates may be examined for the scholarships of the Association in the Stevens Institute of Technology, Hoboken, New Jersey.

Acceptable candidates for the scholarship shall be, first, sons of members or of deceased members of the Association. If there is not a sufficient number of such applicants for the June examination, then applications will be received from other railroad employes or the sons of other railroad employes for the fall examination. The Secretary shall issue a proper circular in this case as before. In extending the privilege outside of the families of members, preference shall be given to employes or the sons of employes, or the sons of deceased employes of the mechanical departments.

Candidates for these scholarships shall apply to the Secretary of this Association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The successful candidate shall be required to take the course of mechanical engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SECTION 1. The officers of the Association, except the Secretary as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections

shall not be postponed. The President, Vice-Presidents and Treasurer shall hold office for one year, and Executive members for two years, or until successors are chosen, provided, however, that three Executive members shall be elected for one year at the time of the adoption of this amendment. Three Executive members shall be elected each year thereafter.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the results.

SEC. 3. A Secretary from among the members of the Association shall be appointed by a majority of the Executive Committee at its first meeting after the annual election, or as soon thereafter as the votes of a majority of the members of the Executive Committee can be secured for a candidate. The term of office of the Secretary thus appointed, unless terminated sooner, shall cease at the first meeting, after the next annual election succeeding his appointment, of the Executive Committee organized for the transaction of business. Two-thirds of the members of the Executive Committee shall have power to remove the Secretary at any time. His compensation, if any, shall be fixed for the time that he holds office by vote of the majority of the Executive Committee. He shall also act as Secretary of the Executive Committee.

ARTICLE IX.

AUDITING COMMITTEE.

SECTION 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the Association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the Association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a commitee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the Association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the Association approved of subjects for investigation, the President shall appoint individuals or special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report

on any subject which a majority of the members present may approve; or individual papers may be presented to the Association after approval by the Executive Committee. Papers and reports shall be presented by abstracts, which shall not occupy more than ten minutes in the reading unless otherwise ordered by the Association.

RECOMMENDATIONS OF STANDARDS.

SEC. 4. Any proposition recommending the adoption of standard construction or practice shall be in writing and be accompanied by drawings, if the latter are necessary for a clear understanding of the subject. Such proposition shall then be submitted to the Association for discussion, after which a vote shall be taken to decide whether the proposition shall be submitted for decision by letter ballot to all the members entitled to vote. If decided in the affirmative, the Secretary, within three months from the time the vote of the Association is taken on such measure, shall send by mail to each member a blank ballot, and a copy of the proposed recommendation, with a report, to be approved by the Executive Committee, of the discussion thereon; such ballot to be filled up, signed and remailed to the Secretary, who will count all the ballots received within thirty days from the date they were sent to the members, and he shall then announce the vote in such manner as the Executive Committee may prescribe. Any recommendation securing two-thirds of the votes cast shall be adopted by the Association.

SEC. 5. All reports, resolutions and recommendations involving the use, or proposed use, by railroad companies, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Association only by the Executive Committee.

ARTICLE X.

AMENDMENTS.

SECTION 1. The Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

BY-LAWS.

TIME OF MEETING.

I. The regular meeting of the Association shall be held annually in June of each year.

HOURS OF SESSION.

II. The regular hours of session shall be from 9:30 o'clock A.M. to 1:30 o'clock P.M.

PLACE OF MEETING.

III. The time and place for holding the Annual Convention shall be selected by a Joint Committee composed of the President, three Vice-Presidents and Treasurer of this Association and a corresponding committee from the Master Car Builders' Association. This Joint Committee shall meet within six months after the convention and decide upon the time and place of meeting.

QUORUM.

IV. At any regular meeting of the Association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this Association shall, unless otherwise ordered by a vote, proceed in the following order:

1. Opening prayer.
2. Address by the President.
3. Acting on the minutes of the last meeting.
4. Reports of Secretary and Treasurer.
5. Assessment and announcement of annual dues.
6. Election of Auditing Committee.
7. Unfinished business.
8. New business.
9. Reports of committees.

10. Reading of papers and discussion of questions propounded by members.
11. Routine and miscellaneous business.
12. Election of officers.
13. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P.M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the Association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken, and no member shall have the floor more than five minutes at a time unless otherwise ordered.

NAMES AND ADDRESSES OF MEMBERS.

Active members are shown in Roman letters; representative members in italics.

ACTIVE MEMBERS.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Adams, A. B		G. F., Gulf, Colo. & Santa Fe.	Temple, Tex.
1903	Adams, A. C		M. M., Chicago, Burlington & Quincy.	Alliance, Neb.
1896	Adams, T. E.		G. M. M., St. Louis Southwestern	Pine Bluff, Ark.
1888	Addis, J. W.		S. M., P. & R. S., Texas & Pacific.	Marshall, Tex.
1895	Aiken, C. L		Boston & Maine	South Lawrence, Mass.
1907	Akans, Geo		M. M., Southern	Selma, Ala.
1906	Albright, J. S		M. M., Mexican Interoceanic	Puebla, Mex.
1887	Aldcorn, Thos		Chicago Pneumatic Tool Co	95 Liberty st., N. Y. City.
1902	Aldana, H. Lopez.		S. M. P., Central Northern	Tucuman, Arg. Rep., S.A.
1906	Allen, C. E.		M. M., Northern Pacific.	Glendive, Mont.
1906	Allen, C. W.		G. F., Philadelphia & Reading.	Reading, Pa.
1892	Allen, G. S.		M. M., Philadelphia & Reading	Tamaqua, Pa.
1907	Allport, J. S		G. F., Copper Range	Houghton, Mich.
1904	Allport, Wm		M. M., Zuni Mountain	Ketner, N. M.
1895	Amann, W. E.		Galena Signal Oil Co	520 Rialto Building, San Francisco, Cal.
1903	Anthony, F. S.			148 W. Douglas st., Reading, Pa.
1892	Antz, Oscar		G. L. I., New York Central Lines	Dunkirk, N. Y.
1906	Appler, A. B.		M. E., Delaware & Hudson Co.	Green Island, N. Y.
1887	*Arp, W. C.*	211	*S. M. P., Vandalia.*	*Terre Haute, Ind.*
1905	Arthur, C. G		M. M., Southern	Columbia, S. C.
1903	Ashton, Harry			401 Delaware ave., Toronto, Ont., Can.
1901	Ashworth, Jas.		M. M., Louisville & Nashville	Birmingham, Ala.
1905	Asselin, George		P. E. M. P., Northern Ry. of France	Paris, France.
1890	Atkinson, R.		M. M., Philadelphia & Reading	Reading, Pa.
1896	Atterbury, W. W.		G. M., Pennsylvania.	Philadelphia, Pa.
1887	Augustus, W		M. M., Chicago, Burlington & Quincy.	Centerville, Iowa.
1886	Austin, W. L.		Baldwin Locomotive Works	Philadelphia, Pa.
1907	Ayers, A. R.		Supt. Shops, Lake Shore & Mich. Southern.	Elkhart, Ind.
1903	Ayers, H. B.		The Locomotive & Machine Co	Montreal, Can.
1896	Babcock, C. M		M. M., Texas & Pacific	McDonoghville, La.
1898	Baker, C. F.			1314 Continental Bldg., Baltimore, Md.
1902	Baker, P. G.		M. M., Panama.....24 State st., New York.	Colon (Aspinwall).
1905	Balderston, J. W			2201 East 3d st., Los Angeles, Cal.
1901	Ball, H. F		V. P., American Loco. Co.	111 Broadway, New York.
1905	Barclay, F. B		M. M., Illinois Central	McComb, Miss.
1906	Bardsley, A		M. M., Gulf & Ship Island.	Gulfport, Miss.
1894	Barnes, Chas. H.			27 Cypress place, Brookline, Mass.
1904	Barnes, F. P		M. M., Denver & Rio Grande	Grand Junction, Colo.
1888	Barnes, J. B		S. L. & C. D., Wabash.	Springfield, Ill.
1890	Barnum, M. K		Chicago, Burlington & Quincy.	Chicago, Ill.
1906	Barrows, W. H		M. M., K. C. Southern	Shreveport, La.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1895	*Bartlett, Henry*	1060	*S. M. P., Boston & Maine*	*Boston, Mass.*
1904	Barton, T. F		M. M., Illinois Central	Burnside, Chicago, Ill
1899	Bates, F. L			2432 Howard St., Sacramento,
1905	Bather, Fred		M. F., Mexican International	Torreon, Mex.
1889	Bean, S. L		M. S., Santa Fe Lines	Los Angeles, Cal.
1892	Beattie, A. L.		S. M. P., New Zealand Government	Wellington, N. Z.
1899	Beauclerk, T. S.		Central Argentino.	Rosario de Santa Fe, Arg. Rep., S
1894	Beaumont, J. G		Southern Railways of Peru.	Arequipa, Peru.
1892	Bechhold, H. G.		Cleveland Frog & Crossing Co	Cleveland, Ohio.
1903	Benjamin, F. G.		M. M., Chicago & North-Western	Clinton, Iowa.
1905	Bennett, Geo. R		G. F., Mobile & Ohio	Whistler, Ala.
1903	Bennett, W. J.		A. S. M. P., Chgo., Indpls. & Louisville	Lafayette, Ind.
1900	Bentley, H. T.		A. S. M. P. & M., Chicago & North-West	Chicago, Ill.
1806	Bentley, L. L		Oswego Boiler & Engine Co	Beaver Falls, Pa.
1902	Berry, Arthur O		G. F. L. D., Lake Shore & Mich. Southern	Collinwood, Ohio.
1900	Best, W. N			11 Broadway, New Yc
1903	Billingham, R. A		G. M. M., Pitts, Shawmut & Northern	St. Marys, Pa.
1902	Bingaman, Chas. A		Care of S. M. P., Phila. & Reading	Reading, Pa.
1899	Bissett, J. R		M. M., Seaboard Air Line	Raleigh, N. C.
1901	Blake, R. P		A. S. S., Northern Pacific	Brainerd, Minn.
1904	Bock, M. G		S. M. P. & R. S., De Queen & Eastern	De Queen, Ark.
1899	Boldridge, R. M		M. M., Miss. Central.	Hattiesburg, Miss.
1904	Boler, W. L.		M. M., Del., Lack. & Western	Kingsland, N. J.
1904	Booth, J. S		M. M., Carolina & Northwestern	Chester, S. C.
1904	Booth, Thos		M. S., Pecos Valley Lines	Amarillo, Tex.
1897	Bowles, C. K.		M. M., Tidewater & Western	Chester, Va.
1907	Boyden, N. N.		M. M., Southern	Birmingham, Ala.
1895	Bradeen, J. O		M. M., N. Y. Cent. & Hudson River	New Durham, N. J.
1888	Bradley, W. F.		Supt., Ann Arbor	Toledo, Ohio.
1904	Brady, T. F.		S. M., Mapini.	Mapini, Durango, Mex
1894	Branch, Geo. E.			292 Prospect place, Brooklyn, N.
1896	Brangs, P. H.			11 Broadway, New York Ci
1900	Brassell, J. K		M. M., Cal. Northwestern	Tiburon, Cal.
1902	Brazier, F. W		S. R. S., N. Y. Cent. & Hudson River	New York City.
1892	Brehm, W. H		M. M., Mo., Kan. & Tex	Parsons, Kan.
1904	Breneman, H. N.		A. S. M. P., Chicago, Mil. & St. Paul	West Milwaukee, Wis.
1897	Briggs, D. D		M. M., Louisville & Nashville.	Anniston, Ala.
1879	Briggs, R. H.		M. M., St. Louis & San Francisco	Memphis, Tenn.
1898	*Bronner, E. D*	479	*S. M. P., Michigan Central.*	*Detroit, Mich.*
1887	Brooke, Geo. D.		Panama Canal Commission.	Culebra, Canal Zone.
1892	Brown, David		A. S. M. P., Del., Lack. & Western.	Scranton, Pa.
1905	Brown, H. B		M. M., Erie	Cleveland, Ohio.
1891	Brown, W. A.		M. M., Kanawha & Michigan	Middleport, Ohio.
1904	Brown, T. A		S. M. P., Louisiana & Arkansas	Stamps, Ark.
1895	Browne, T. R		Engr., American Car & Foundry Co	25 Broad st., New Yo
1897	Bruce, Geo. A		G. M. M., Great Northern	St. Paul, Minn.
1890	Bruck, Henry T		M. of M., Cumb. & Penna	Mt. Savage, Md.
1882	Bryan, H. S.		S. M. P., Duluth & Iron Range	Two Harbors, Minn.
1906	Bryant, E. G.		D. M. M., International & Great North	Mart, Tex.
1900	Buchanan, A., Jr		S. M. P., Central Vermont	St. Albans, Vt.
1902	Buchanan, Jas			111 South 5th st., Brooklyn, N.
1887	Buchanan, Wm.			26 Fairfield ave., So. Norwalk, Coı
1906	Burel, W. C.		M. M., Mexican Central	Saltillo, Coah, Mex.
1905	Burgis, E. W.		M. M., N. O., Ft. Jackson & Grand Isle	Algiers, La.
1905	Burkheimer, H. W.		M. M., Louisville & Nashville.	Louisville, Ky.
1893	Bush, S. P		Buckeye Steel Castings Co	Columbus, Ohio.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1903	Bushmeyer, C. J.		M. M., Oklahoma Central	Purcell, I. T.
1906	Bussing, G. H		S. M. P. & R. S., Evans. & Terre Haute	Evansville, Ind.
1893	*Butcher, Geo. W.*	*59*	*S. M. P., San Antonio & A. Pass.*	*San Antonio, Tex.*
1904	Cameron, J. E.		M. M., Atlantic & Birmingham	Waycross, Ga.
1903	Campbell, A. A.		M. M., Kansas City Southern	Shreveport, La.
1896	Cannon, T. E.		M. M., Great Northern.	Melrose, Minn.
1905	Cardell, J		M. M., Canadian Pacific.	Calgary, Alberta, Can.
1902	Caracristi, V. Z.			907 Mutual Building, Richmond, Va.
1904	Cargo, B. B		M. M., Lake Terminal	Lorain, Ohio.
1900	Carney, J. A		S. S., Chicago, Burlington & Quincy.	West Burlington, Iowa.
1907	Carroll, J. T.		A. S. S., Lake Shore & Mich. Southern.	Collinwood, Ohio.
1903	Carson, F. L		M. M., El Paso & Northeastern	Alamogordo, N. M.
1907	Carson, H. M.		Asst. to G. M., Pennsylvania	Philadelphia, Pa.
1889	Casanave, F. D.			1710 Market st., Philadelphia, Pa.
1890	Casey, J. J.		Supt., American Car & Foundry Co	Jeffersonville, Ind.
1904	Cassidy, D. E		M. M., Pennsylvania	Allegheny, Pa.
1892	Chamberlin, E.			610 Grand Central Depot, New York City.
1903	Chambers, C. E.		M. M., Central R. R. of N. J.	Jersey City, N. J.
1893	Chambers, John S.		S. M. P., Atlantic Coast Line.	Wilmington, N. C.
1901	Chase, C. F		American Locomotive Co	Manchester, N. H.
1896	Chase, F. A.		G. M. I., Chicago, Burlington & Quincy.	St. Joseph, Mo.
1904	*Chester, W. E*			*118 Gaston st. W., Savannah, Ga.*
1905	Chidley, Joseph.		Lake Shore & Mich. Southern.	Elkhart, Ind.
1906	Chisholm, J. E		G. M. M., Chicago Great Western	Oelwein, Iowa.
1898	Christopher, J		M. M., Toronto, Hamilton & Buffalo.	Hamilton, Ont., Can.
1902	Churchward, G. J.		Great Western.	Swindon, England.
1905	Clark, David.		M. M., Arizona & New Mexico	Clifton, Ariz.
1899	*Clark, F. H.*	*1346*	*G. S. M. P., Chicago, Burl. & Quincy.*	*Chicago, Ill.*
1886	Clark, Isaac W			Fayetteville, N. C.
1903	Clark, J. H.		M. M., Staten Island R. T.	Clifton, S. I., New York.
1897	Clarke, Owen.		M. M., Texas & Pacific.	Marshall, Tex.
1903	Clarkson, W. S		G. M. M., Northern Pacific.	Livingston, Mont.
1901	Clay, S. B			1220 N. 6th st., Ft. Smith, Ark.
1893	Cleaver, F. C.		S. M. P., Rutland	Rutland, Vt.
1877	Clifford, J. G			10th and Kentucky sts., Louisville, Ky.
1887	Cloud, John W			82 York Road, King's Cross, London, Eng.
1903	Cockfield, William		L. & C. S., Mexican	Orizaba, Mexico.
1896	Cole, F. J.		American Locomotive Co	111 Broadway, New York City.
1904	Cole, T. J.		M. M., Erie.	Meadville, Pa.
1907	Collier, L. L.		M. M., Louisiana & North-West.	Gibsland, La.
1905	Collin, George		Northern Ry. of France.	Paris, France.
1907	Collin, J. M		M. M., N. Y., New Haven & Hartford	E. Hartford, Conn.
1906	Collins, W. H		M. M., Fonda, Johnstown & Gloversville.	Gloversville, N. Y.
1906	Conners, J. J		M. M., Chicago, Milwaukee & St. Paul.	Dubuque, Iowa.
1890	*Conolly, J. J.*	*93*	*S. M. P., Dul., So. Shore & Atlantic.*	*Marquette, Mich.*
1879	Cook, John S.		M. M., Georgia.	Augusta, Ga.
1904	Cooper, F. R		S. M. P., South Buffalo.	Buffalo, N. Y.
1907	Cooper, G. W		M. M., Mexican Central	Aquascalientes, Mex.
1902	Cota, A. J		M. M., Chicago, Burlington & Quincy.	Chicago, Ill.
1904	Coutant, M. R.		M. M., Ulster & Delaware	Rondout, N. Y.
1900	Crawford, D. F		G. S. M. P., Pennsylvania Lines.	Pittsburgh, Pa.
1904	Cromwell, O. C.		M. E., Baltimore & Ohio.	Baltimore, Md.
1902	Cross, C. W.		Supt. Apprentices, N. Y. Cent. Lines.	New York City.
1893	*Cross, W.*	*504*	*Asst. to 2d V. P., Canadian Pacific*	*Winnipeg, Man., Can.*

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1899	Cumback, R. O.		S. S., Central R. R. of New Jersey	Plainfield, N. J.
1906	Cunningham, D. W		M. M., Chicago, Rock Island & Pacific	Valley Junction, Iowa.
1900	Curley, M. S		S. M. P., Sierra Ry. of Cal	Jamestown, Cal.
1903	Curry, H. M		G. M. M., Northern Pacific	St. Paul, Minn.
1903	Curtis, Theo. H.		S. M., Louisville & Nashville	Louisville, Ky.
1904	Cutler, T. J		M. M., Northern Pacific	Missoula, Mont.
1899	Davis, Chas. H			So. Yarmouth, Mass.
1906	Davis, David, E.		M. M., Boston & Maine	Concord, N. H.
1892	Davis, Ed. E.			Madison ave. and 93d st., New York City.
1900	Davisson, F. E		S. M., San Pedro, Los. Ang. & Salt Lake	Los Angeles, Cal.
1897	Dawson, E.			Osceola, Iowa.
1903	Dawson, L. L		M. M., Illinois Central	McComb, Miss.
1896	Deeble, Wm. R.		Tasmania Government	Launceston, Tasmania.
1891	*Deems, J. F.*	2881	*G. S. M. P., New York Central Lines*	*New York City.*
1905	Deeter, D. H.		M. M., Philadelphia & Reading	Reading, Pa.
1896	De Gress, C.		Mexican National Construction Co	Colima, Mex.
1897	Delaney, C. A.		American Locomotive Co	Scranton, Pa.
1895	Delaney, H			14 Stuyvesant place, Staten Island, N. Y
1905	Delaney, S. J.		M. M., N. Y. C. & H. R. R. R.	New York City.
1899	Delano, F. A		Prest., Wabash	Chicago, Ill.
1900	Demarest, T. W		S. M. P., Pennsylvania Lines	Ft. Wayne, Ind.
1905	Desmond, D. G.		M. M., Morgantown & Kingwood	Morgantown, W. Va.
1903	Deverell, A. C		A. S. M. P., Great Northern	St. Paul, Minn.
1907	De Voy, J. F.		M. E., Chicago, Milwaukee & St. Paul	W. Milwaukee, Wis.
1905	Dewey, J. J		M. M., Erie	Galion, Ohio.
1896	Dickerson, S. K		A. S. M. P., Lake Shore & Mich. Southern	Cleveland, Ohio.
1887	Dickson, G. L.		American Locomotive Co	Scranton, Pa.
1902	Dickson, Geo.		M. M., Chicago, Cincinnati & Louisville	Peru, Ind.
1905	Dickson, John.		M. M., Great Northern	Grand Forks, N. D.
1907	Diehr, C. P		M. M., N. Y. Central & Hudson River	Jersey Shore, Pa.
1900	Dillon, S. J		M. M., Pennsylvania	South Amboy, N. J.
1905	Dinan, Arthur.		M. M., Atchison, Topeka & Santa Fe	Newton, Kan.
1905	Dinkel, M. C		S. M. P. & M., Ixt., Mani & Nijini Ry.	Ixtlahuaca, Mex.
1894	Dixon, W. F			Podolsk, Moscow, Govt., Russia.
1897	Doebler, C. H			Ft. Wayne, Ind.
1905	Dolan, J. P		M. M., St. Louis & No. Arkansas	Eureka Springs, Ark.
1898	Dolan, S. M.		M. M., Missouri Pacific	Sedalia, Mo.
1904	Dooley, W. H.		M. M., Cin., New Orleans & Tex. Pac.	Chattanooga, Tenn.
1903	Doonan, W. F.		M. M., Great Northern	Whitefish, Mont.
1907	Dorsey, J. P		M. M., Baltimore & Ohio	Parkersburg, W. Va.
1893	Dow, Jas. M			Kenton, Ohio.
1899	Downing, T. M.		M. M., Virginia & Carolina Coast	Suffolk, Va.
1893	Drury, Michael J		M. M., Atchison, Topeka & Santa Fe	Winslow, Ariz.
1904	Dunham, W. E.		M. M., Chicago & North-Western	Winona, Minn.
1900	*Dunn, A. J*	20	*M. M., Virginia & Southwestern*	*Bristol, Va.*
1896	*Dunn, J. F*	190	*S. M. P., Oregon Short Line*	*Salt Lake City, Utah.*
1904	Durborow, R. N		S. M. P., Pennsylvania	Altoona, Pa.
1906	Durham, H. P.		S. M. P., Tehuantepec National	Rincon, Ant., Oaxaca, Mex.
1906	Durrell, D. J.		A. S. M. P., Pennsylvania Lines	Columbus, Ohio.
1906	Edmonds, G. S.		M. M., Delaware & Hudson Co.	Oneonta, N. Y.
1905	Edmondson, W. G.		E. of T., Philadelphia & Reading	Reading, Pa.
1899	Egan, J. A.		G. F., Mexican Southern	Oaxaca, Mex.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1900	Elden, Edw		M. M., N. Y. C. & H. R. R. R.	East Buffalo, N. Y.
1906	Elliott, J. B.		G. M. M., Canadian Pacific	Montreal, Can.
1899	Ellis, H. D.		Anglo-Chilian Nitrate & Railway Co.	Tocapilla, Chili.
1893	Ellis, John J		S. M. P. & M., C. St. P. M. & O.	St. Paul, Minn.
1906	Elordi, Manuel		Gen. Insp., Argentine Govt. Ry.	New York City.
1901	Emerson, G. H.		S. M. P., Great Northern.	St. Paul, Minn.
1906	Emerson, H.		American Locomotive Co	111 Broadway, N. Y. City.
1893	English, H. W.			Birmingham, Ala.
1893	English, Richard			114 Shotwell st., San Francisco, Cal.
1905	Enright, J. F.		M. M., Mobile & Ohio	Whistler, Ala.
1898	Ettinger, R. L.		C. M. E., Southern.	Washington, D. C.
1907	Evens, J. W		M. M., Alabama Great Southern	Birmingham, Ala.
1900	Ewing, J. J		M. E., Chesapeake & Ohio	Richmond, Va.
1904	Farrell, R. J			Sparta, Ill.
1900	*Feeley, T. M*	*88*	*M. M., Iowa Central.*	*Marshalltown, Iowa.*
1885	Ferguson, G. A		Boston & Albany R. R	So. Station, Boston, Mass.
1905	Ferguson, L. B.		M. M., Vicksburg, Shreveport & Pacific.	Monroe, La.
1904	Ferguson, T. G.		Cordova & Rosario.	Rosario, Arg. Rep., S. A.
1904	Fetner, W. H		M. M., Central of Georgia	Macon, Ga.
1901	Fildes, Thos.			Richmond Hill, L. I., N. Y.
1907	Finch, Roland.		Beyer, Peacock & Co.	Yokohama, Japan.
1907	Fisher, O. A.		M. M., Atchison, Topeka & Santa Fe	Wellington, Kan.
1905	Fitzgerald, W. T.		M. M., Wisconsin & Michigan.	Peshtigo, Wis.
1892	Fitzmorris, Jas		M. M., Chicago Junction	Union Stock Yards, Chicago, Ill.
1906	Flavin, J. T.		M. M., Ind., Ill. & Southern.	Kankakee, Ill.
1903	Fleischer, J. F.		M. M., Chicago & North-Western	Sioux City, Iowa.
1903	Flory, B. P		M. E., Central of New Jersey	Jersey City, N. J.
1901	*Fogg, J. W*	*39*	*M. M., Chicago Terminal Transfer*	*East Chicago, Ind.*
1896	*Foque, T. A.*	*155*	*M. S., M. St. Paul & Sault Ste. Marie.*	*Minneapolis, Minn.*
1905	Ford, Daniel W		M. M., Pacific Coast	San Luis Obispo, Cal.
1905	Forster, John		M. M., St. Louis & San Francisco	Kansas City, Mo.
1900	Forsyth, A.		S. S., Chicago, Burlington & Quincy.	Aurora, Ill.
1888	Forsyth, Wm		M. E., *The Railway Age.*	Chicago, Ill.
1904	Foster, W. T		M. M., Tennessee Copper Co.'s Ry.	Copperhill, Tenn.
1877	Fowle, I. W.			Riverside, Cal.
1907	Fowler, Henry		Asst. Wks. Mgr., Midland Ry. of England.	Derby, England.
1906	Franey, M. D		S. S., Lake Shore & Mich. Southern	Collinwood, Ohio.
1907	Fraps, J. C.		M. M., Aberdeen & Ashboro	Biscoe, N. C.
1907	Fraser, Thos		M. M., Algoma Central	Sault Ste. Marie, Ont.
1906	French, G. W		M. M., Little Rock & Hot Spgs. Western.	Hot Springs, Ark.
1891	French, R. E.		Southern Pacific	Oakland, Cal.
1898	Frey, N		M. M., Chicago, Burlington & Quincy,	La Crosse, Wis.
1906	Friere, de Silva, J. G		L. S., Central Ry. of Brazil	Rio de Janeiro, Brazil, S. A.
1904	Fries, A. J.		M. M., Boston & Albany	Allston, Mass.
1903	Fryburg, F. M.		M. M., Great Northern.	Minot, N. D.
1890	*Fuller, C. E.*	*234*	*S. M. P., Chicago & Alton*	*Bloomington, Ill.*
1907	Fulmer, J. H.		M. M., Pennsylvania	Pottsville, Pa.
1897	Gaines, F. F		S. M. P., Central of Georgia	Savannah, Ga.
1904	Gairns, A. H.		M. M., Denver & Rio Grande	Denver, Colo.
1891	Galbraith, R. M		S. M., K. C. Southern	Pittsburg, Kan.
1901	Gallagher, G. A.		M. M., Illinois Southern.	Sparta, Ill.
1904	Galloway, W. S.		Baltimore & Ohio	Camden Station, Baltimore, Md.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1904	Gannon, J. B.		M. M., N. Y., New Haven & Hartford	New London, Conn.
1887	Garstang, Wm.		S. M. P., C. C. C. & St. L	Indianapolis, Ind.
1900	Gaskins, W. B.		M. M., Missouri Pacific	Osawatomie, Kan.
1903	Gauthier, Jesse		M. M., Copper Range.	Houghton, Mich.
1886	Gentry, T. W		American Locomotive Co	Richmond, Va.
1905	George, Wm. E.		Western Australian Rys	Perth, Australia.
1899	Gibb, T. M.		G. S., Crystal River	Redstone, Colo.
1888	Gibbs, A. W		G. S. M. P., Pennsylvania.	Altoona, Pa.
1890	Gibbs, George			10 Bridge st., New York.
1902	Gibson, J. A		M. M., C. C. C. & St. L	Urbana, Ill.
1904	Gilbert, E. B.		S. M. P., Bessemer & Lake Erie.	Greenville, Pa.
1905	Gilbert, F. M.		M. E., N. Y. C. & H. R. R. R	G. C. Sta., N. Y. City.
1896	Gill, John.		S. M. P., Chicago, Indplis. & Louisville.	Lafayette, Ind.
1905	Gillett, L. D		M. M., Norfolk & Western	Bluefield, W. Va.
1891	Gillis, H. A		Auto-Car Co.	Ardmore, Pa.
1883	Gilmore, W. L.			Elkhart, Ind.
1893	Gilmour, George		Travelers' Insurance Co.	Hartford, Conn.
1891	Glass, John C		M. M., Pennsylvania	Verona, Pa.
1905	Goodale, R. J		M. M., Illinois Central	Centralia, Ill.
1904	Goodman, J. E.		M. M., Northern Pacific.	Duluth, Minn.
1907	Goodrich, G. P		M. M., Ft. Smith & Western.	Ft. Smith, Ark.
1905	Goodrich, Max		M. M., New York & Ottawa	Ottawa, Ont., Can.
1880	Gordon, H. D			71 John st., New York.
1906	Gossett, C. E.		M. M., Chicago, Rock Island & Pacific	Eldon, Mo.
1900	Gould, J. E		S. M. P., Norfolk & Southern.	Berkley, Va.
1904	Gould, J. R.		M. M., Chesapeake & Ohio	Richmond, Va.
1899	Gould, R		Buenos Ayres Great Southern	River Plata House, Finsbury Circus, London, England.
1892	Graham, Charles.		M. M., Philadelphia & Reading	Reading, Pa.
1894	Graham, J. A		G. F., Louisville & Nashville	Columbia, Tenn.
1903	Graham, S. C.		M. M., Chicago & North-Western	Lake City, Iowa.
1903	Grandy, W. S		D. F., Atchison, Topeka & Santa Fe.	Bakersfield, Cal.
1894	Grant, A. S		M. M., Missouri Pacific	De Soto, Mo.
1906	Gray, B. H		M. M., New Orleans Terminal	New Orleans, La.
1906	Gray, G. M		M. E., Bessemer & Lake Erie.	Greenville, Pa.
1906	Greard, Henry Octave.		A. S. M. P., French State Rys	Paris, France.
1889	Greatsinger, J. L.		Brooklyn Rapid Transit	Brooklyn, N. Y.
1897	Greaven, Luis		S. M. P., Buenos Ayres Gt. Sou.	Buenos Ayres, Arg. Rep., S. A.
1905	Green, H		M. E., So. Balto. Steel Car & Fdy. Co	Baltimore, Md.
1895	Green, Wilbur.		M. M., San Antonio & Aransas Pass	Yoakum, Tex.
1905	Greenwood, B. E		G. F., Seaboard Air Line Ry	Portsmouth, Va.
1885	Griffith, Fred B			797 Elmwood ave., Buffalo, N. Y.
1907	Griffith, R		M. M., Colorado Midland.	Colorado City, Colo.
1893	Gross, R. J.		American Locomotive Co	New York.
1896	Groves, J. R			Denver, Colo.
1900	Gurry, Geo		G. S., American Locomotive Co.	Allegheny, Pa.
1906	Guthbrod, F. W.		Prussian State Rys.	Berlin, Germany.
1893	Hainen, J.		G. M. M., Southern.	Greensboro, N. C.
1898	*Hair, John.*	*194*	*S. M. P., Baltimore & Ohio S.-W*	*Cincinnati, Ohio.*
1906	Hale, H. H		A. M. M., Pere Marquette	Grand Rapids, Mich.
1904	Hall, Chas. S.		M. M., Boston & Maine.	Springfield, Mass.
1904	Hall, Grant		A. S. M. P., Canadian Pacific	Winnipeg, Man., Can.
1907	Hamilton, W. H.		M. M., Atchison, Topeka & Santa Fe	Argentine, Kan.

NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
Hammett, P. M.	167	*S. M. P., Maine Central*	*Portland, Me.*
Hammond, G. O.		M. E., Erie.	Meadville, Pa.
Hancock, Geo. A		S. M. P., St. Louis & San Francisco	Springfield, Mo.
Hancock, Wm. S			3654 Olive st., St. Louis, Mo.
Hardie, R. J		Union Foundry & Machine Works.	Valparaiso, Chili.
Harkon, J. W		G. S., Canada Foundry Co	Toronto, Can.
Harrigan, P. J.		M. M., Baltimore & Ohio.	Connellsville, Pa.
Harrington, H. H.		M. M., Erie	Susquehanna, Pa.
Harris, C. M		M. M., Washington Terminal	Washington, D. C.
Harris, J. D.		Westinghouse Air Brake Co	Wilmerding, Pa.
Harrison, F. J.		M. M., Buffalo, Rochester & Pittsburg	Du Bois, Pa.
Harrison, John		San Paulo.	San Paulo, Brazil, S. A.
Harrison, W. L.		A. S. M. P., Chicago, Rock Island & Pac.	Chicago, Ill.
Hartigan, B.		G. F., Rutland	Rutland, Vt.
Haselton, G. H		S. M. P., N. Y. C. & H. R. R. R.	West Albany, N. Y.
Haskell, B.			Franklin, Pa.
Hassman, Wm		M. M., Peoria & Pekin Union.	Peoria, Ill.
Hatz, G. K		M. M., Chicago & Alton.	Bloomington, Ill.
Hawkins, B. H.		M. M., Del., Lack. & Western	Buffalo, N. Y.
Hawkins, R. D.		G. M. M., Great Northern	Minot, N. D.
Hawksworth, D		Chicago, Burlington & Quincy	Plattsmouth, Neb.
Hawthorne, J			Susquehanna, Pa.
Hayes, J. T.		M. M., Grand Rapids & Indiana	Grand Rapids, Mich.
Hayes, W. C		Supt., Erie	Susquehanna, Pa.
Haynen, W. J		M. M., Mississippi Central	Hattiesburg, Miss.
Hayward, H. S		S. M. P., Pennsylvania	Jersey City, N. J.
Hedley, F.		G. M., Interborough R. T. Ry. Co.	New York City.
Heintzleman, T. W		S. M. P., Southern Pacific.	Sacramento, Cal.
Henderson, G. R			20 W. 34th st., New York
Henry, Wm.		A. M. M., St. Louis & San Francisco.	Memphis, Tenn.
Herr, E. E.		M. M., Pennsylvania	Camden, N. J.
Herr, Edwin M			Edgewood Park, Pa.
Herr, H. T.			Duquesne, Ariz.
Hibbard, H. Wade.		Cornell University	Ithaca, N. Y.
Hickey, F. P		American Locomotive Co	Richmond, Va.
Hickey, P. J		M. M., C. C. C. & St. L	Mattoon, Ill.
Hicks, I. C.		M. M., Santa Fe Lines	San Bernardino, Cal.
Higgins, S		G. M., N. Y., New Haven & Hartford	New Haven, Conn.
Hildreth, F. F.		M. M., Vandalia	Terre Haute, Ind.
Hilferty, C. D.		Cooke Locomotive Works	Paterson, N. J.
Hill, Jas. W.			Peoria, Ill.
Hill, John		M. M., Lake Erie & Western	Lima, Ohio.
Hill, Rufus		M. M., Pennsylvania	Pavonia, N. J.
Hill, W. H.		M. M., Cornwall	Lebanon, Pa.
Hillman, C. R		A. S. M. P., San Paulo.	San Paulo, Brazil, S. A.
Hinckley, A. C		M. M., Cincinnati, Hamilton & Dayton	Lima, Ohio.
Hobbs, H. L		M. M., South & Western.	Johnson City, Tenn.
Hobson, W. P.		A. M. M., Chesapeake & Ohio.	Lexington, Ky.
Hocking, Jas		M. M., N. Y., New Haven & Hartford	Norwood Central, Mass.
Hodges, A. H		M. M., Baltimore & Ohio.	Cumberland, Md.
Hoffman, C. M		M. M., Southern	Princeton, Ind.
Hoffman, R. F			10 Bloom st., Danville, Pa.
Hogan, C. H		D. S. M. P., N. Y. C. & H. R. R. R	Depew, N. Y.
Holland, W. D			313 E. Farrar st., Moberly, Mo.
Homer, John C		A. M. M., Cin., Hamilton & Dayton	Indianapolis, Ind.
Hopwood, John		Argentine Great Western	51 Ennerdale Rd., Richmond, Surrey, Eng.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1896	*Horrigan, John*	138	*S. M. P., E. J. & E., C. L. S. & E. Rys*	*Joliet, Ill.*
1906	Horsey, A. W		M. E., Canadian Pacific	Montreal, Can.
1892	Howard, C. H			504 Columbia Bldg., St. Louis, Mo.
1896	Howard, John		S. M. P., New York Central Lines	New York City.
1905	Howe, H. B.		New South Wales Rys	Sydney, Australia.
1903	Howson, G. N.		M. M., Southern	Birmingham, Ala.
1899	Hudson, H. G			1436 84th st., Cleveland, Ohio
1904	Hudson, W. H		G. M. M., Southern	Birmingham, Ala.
1903	Hufman, W. H		M. M., Chicago & North-Western	Baraboo, Wis.
1890	Hufsmith, F			Palestine, Tex.
1905	Hume, E. S		C. M. E., Western Australian Govt. Rys	Midland Jct., Australia.
1890	Humphrey, A. L.		G. M., Westinghouse Air Brake Co	Pittsburgh, Pa.
1906	Hungerford, S. J.		S. L. Works, Canadian Pacific	Winnipeg, Man.
1904	Hunt, H. B.		American Locomotive Co	Chicago, Ill.
1906	Hunter, G. S		G. M. M., International & Gt. Northern	Palestine, Tex.
1905	Hunter, H. S.		M. M., Philadelphia & Reading	Philadelphia, Pa.
1896	Hyndman, F. T			New Haven, Conn.
1900	Irwin, J. E.		M. M., Marietta, Columbus & Cleveland	Marietta, Ohio.
1907	Jackson, Harry		M. M., Interoceanic	Puebla, Mex.
1907	James, Charles		M. M., Erie	Galion, Ohio.
1899	James, E. T.		M. M., N. Y., New Haven & Hartford	New Haven, Conn.
1896	James, Geo		M. M., N. Y. C. & St. L.	Station S, Chicago, Ill.
1907	Jaynes, R. T.		M. M., Lehigh & Hudson River	Warwick, N. Y.
1900	Jennings, Thos		M. M., Boston & Maine	Keene, N. H.
1890	Jennings, Wm.		Pacific Electric Ry	Los Angeles, Cal.
1896	Johnson, A. B.		Baldwin Locomotive Works	Philadelphia, Pa.
1902	Johnson, Ben.		S. M., Mexican Central	Aguascalientes, Mex.
1887	Johnson, L. R.		S. M. P., Canadian Pacific	Montreal, Can.
1903	Johnson, R. A.			Guaymas, Sonora, Mex.
1898	Johnson, R. H.			Ortega, Mexico, D. F.
1903	Johnson, W. O			627 Ry. Exchange Bldg., Chicago, Ill.
1905	Jones, C. F.		M. M., Natchez, Urania & Ruston	Urania, La.
1888	Joughins, G. R		M. S., Intercolonial	Moncton, N. B., Can.
1903	Jungling, M			318 Read st., Kingwood, Ga.
1896	Justice, D. J.			722 W. Chestnut st., Louisville, Ky.
1905	Kaderly, W. F		M. M., Southern	Alexandria, Va.
1890	Kalbaugh, I. N.		Coal & Coke Ry	Gassaway, W. Va.
1903	*Kapp, W. F.*	51	*S. S. & M., Rich., Fred. & Potomac*	*Richmond, Va.*
1907	Kastlin, Jacob.		Supt, Davenport Loco. Works	Davenport, Iowa.
1904	Kearney, Alex.		A. S. M. P., Norfolk & Western	Roanoke, Va.
1892	*Keegan, Jas. E*	92	*S. M. P., Grand Rapids & Indiana*	*Grand Rapids, Mich.*
1904	Kellogg, W. L.		M. M., Pere Marquette	Grand Rapids, Mich.
1896	Kells, Willard.		M. M., Lehigh Valley	Sayre, Pa.
1896	Kelly, Wm.		G. M. M., Great Northern	Spokane, Wash.
1905	Kendall, H. H.		M. M., St. L., Brownsville & Mexico	Kingsville, Tex.
1904	Kendig, R. B.		M. E., Lake Shore & Mich. Southern	Cleveland, Ohio.
1894	Kennedy, Jas			158 Prospect st., Cambridge, Mass.
1901	Keyworth, T. E		Cuban Central Rys., Ltd.	Sagua La Grande, Cuba.
1890	Killen, W. E.			Jacksonville, Ill.
1903	Kilpatrick, J. B		A. S. M. P., Chicago, R. I. & Pacific	Chicago, Ill.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1900	Kilpatrick, R. F		S. M. P., Del., Lack. & Western	Scranton, Pa.
1903	Kinnaird, L. S		M. M., Cleveland, Akron & Columbus	Mt. Vernon, Ohio.
1905	Kinney, W. H.		M. M., New York, Ontario & Western	Mayfield, Pa.
1902	Kipp, A. R		The Arnold Co.	Chicago, Ill.
1904	Kirkpatrick, Jas		M. M., Baltimore & Ohio	Newark, Ohio.
1902	Knight, Wm. Edw		G. M. M., United Rys. of Havana	Havana, Cuba.
1902	Krauss, J. I.		M. M., K. C. Southern	Mena, Ark.
1905	Kyle, C.		M. M., Canadian Pacific	Montreal, Can.
1899	Lachlan, Wm		Manaos Improvements, Ltd	Manaos, Amazomas, Brazil.
1898	Lake, E. M		Camp & Hinton Co.	Lumberton, Miss.
1888	Lape, C. F		Scully Steel & Iron Co.	Chicago, Ill.
1907	Larry, W. L		M. M., N. Y., New Haven & Hartford	Taunton, Mass.
1907	*Latta, H. P*		*S. M. P., Mobile, Jackson & Kansas City*	*Mobile, Ala.*
1905	Laurent, Théo.		A. C. E., Paris & Orleans Ry	Paris, France.
1891	Lawes, T. A.		M. E., New York, Chicago & St. Louis	Cleveland, Ohio.
1896	Lawrence, J. L		G. F. S., Cumberland Valley	Chambersburg, Pa.
1890	Leach, H. L.		A. S. M. P., Bangor & Aroostook	Houlton, Me.
1903	Leach, W. B			383 Dorchester ave., South Boston, Mass.
1892	Lee, C. W			Greensboro, N. C.
1904	Leeman, W. W			Goodland, Kan.
1888	Leigh, F. J.			30 Kenilworth Road, Ealing, London, W., Eng.
1890	Leonard, A. G.		Union Stock Yards	Chicago, Ill.
1876	*Lewis, W. H*	*697*	*S. M. P., Norfolk & Western*	*Roanoke, Va.*
1907	Lillie, G. W		S. C. D., St. Louis & San Francisco	St. Louis, Mo.
1906	Lindsley, W. H.		M. M., Florida Ry	Alton, Fla.
1904	Link, T. C		Union Iron & Brass Works	El Paso, Tex.
1896	Linstrom, Chas		M. M., Illinois Central	Vicksburg, Miss.
1907	Little, J. C.		M. E., Chicago & North-Western	Chicago, Ill.
1903	Litton, Francis H.		Shansi Honan Ry	Chiaotso, Honan, China.
1890	*Lloyd, T. S*	*1287*	*G. S. M. P., Chicago, R. I. & Pacific*	*Chicago, Ill.*
1905	Lockwood, B. D		M. E., Clev., Cin., Chicago & St. Louis	Indianapolis, Ind.
1895	Lonergan, P. T		M. M., Boston & Albany	W. Springfield, Mass.
1907	Lord, A. W		S. M. P., Quincy & Torch Lake	Hancock, Mich.
1899	Lovell, Alfred		S. M., Atchison, Topeka & Santa Fe	Chicago, Ill.
1903	Lyddon, H. A		G. L. F., Northern Pacific	N. Brainerd, Minn.
1905	Lynn, M. J.		M. M., Buffalo, Rochester & Pittsburgh	Salamanca, N. Y.
1894	Lyon, Tracy		Westinghouse Electric & Mfg. Co	Pittsburgh, Pa.
1903	MacBain, D. R.		A. S. M. P., Michigan Central	Detroit, Mich.
1907	Macbeth, H. A		M. M., N. Y., Chicago & St. Louis	Conneaut, Ohio.
1890	Macfarlane, T. W		Mobile, Jackson & Kansas City	Louisville, Miss.
1899	Machesney, A. G		Baldwin Locomotive Works	Philadelphia, Pa.
1904	Machin, A. M		M. M., St. L., Iron Mntn. & Southern	Baring Cross, Ark.
1876	Mackenzie, John.			60 Hawthorne ave., Cleveland, Ohio.
1905	Magarvey, J. R.		American Locomotive Co	Dunkirk, N. Y.
1896	Maher, P		S. M. P., Toledo, St. Louis & Western	Frankfort, Ind.
1896	Mahl, F. W		M. E., Southern Pacific	San Francisco, Cal.
1905	Mailer, John		M. M., Ft. Smith & Western	Ft. Smith, Ark.
1899	Malone, I. M.			Chihuahua, Mex.
1895	Mallinson, E. P.			49 Ashford st., Brooklyn, N. Y.
1904	Malthaner, W		M. M., Delaware & Hudson	Green Island, N. Y.
1894	Manchester, A. E.		S. M. P., C. M. & St. P	West Milwaukee, Wis.
1902	Manchester, H. C.		M. M., Maine Central	Portland, Me.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1893	*Manning, J. H.*	336	*S. M., Delaware & Hudson*	*Albany, N. Y.*
1905	Mannion, T. D		M. M., Philadelphia & Reading	Camden, N. J.
1898	Marchbanks, James		Wellington & Manawatu	Wellington, N. Z.
1903	Markle, T. M.			Reno, Nev.
1890	Marshall, E. S.			St. Louis, Mo.
1906	Marshall, Thos		M. M., C. St. P. M. & O. Ry.	St. Paul, Minn.
1891	Marshall, W. H.		Prest., American Locomotive Co.	New York City.
1903	May, H. C		M. M., C. C. C. & St. L	Louisville, Ky.
1907	May, Walter		M. M., Cleve., Cin., Chicago & St. Louis.	Louisville, Ky.
1904	Maysilles, J. H			108 Elmer ave., Schenectady, N. Y.
1906	McArthur, F. A.		M. M., St. Louis & San Francisco	Springfield, Mo.
1905	McCarthy, M. J.		M. M., Lake Shore & Mich. Southern	Elkhart, Ind.
1891	McConnell, J. H			1503 Arrott Bldg., Pittsburg, Pa.
1896	McCormick, A.		F. M. Hicks & Co.	Chicago Heights, Ill.
1892	*McCuen, J. P.*	230	*S. M. P., C. N. O. & T. P. and A. G. S. Rys.*	*Ludlow, Ky.*
1903	McCuen, R. E		M. M., Lexington & Eastern.	Lexington, Ky.
1891	McDonough, James			Galveston, Tex.
1905	McDougall, R. M		M. M., Morenci Southern.	Morenci, Ariz.
1893	McElvaney, C. T.		M. M., Missouri, Kansas & Texas	Denison, Tex.
1893	*McGee, G. S.*	219	*S. M. P., Mobile & Ohio*	*Mobile, Ala.*
1905	McGoff, J. H		M. M., Atchison, Topeka & Santa Fe	Ft. Madison, Iowa.
1903	McGrath, J. T.		M. M., Grand Trunk.	Ft. Gratiot, Mich.
1905	McHaffie, A. B		M. M., Intercolonial	Moncton, N. B., Can.
1903	McHattie, T.		M. M., Grand Trunk.	Montreal, Can.
1890	McIntosh, Wm		S. M. P., Central R. R. of N. J.	Jersey City, N. J.
1901	McKeen, W. R., Jr.		S. M. P., Union Pacific	Omaha, Neb.
1896	McLean, W. J		M. M., Bell., Bay & Brit. Col.	Bellingham, Wash.
1901	McLeish, W. J.			Evansville, Ind.
1906	McManamy, J		A. M. M., Pere Marquette	St. Thomas, Ont., Can.
1894	McMasters, Chas. J.		M. M., Rutland	Malone, N. Y.
1896	McNabb, T		M. M., A. R. & C. Co	Lethbridge, Alb., Can.
1890	McNaughton, Jas.		American Locomotive Co	Schenectady, N. Y.
1905	McNulty, F. M		M. M., Monongahela Connecting	Pittsburgh, Pa.
1905	McRae, J. A		M. E., Michigan Central	Detroit, Mich.
1888	Medway, John.			7 Hawthorne ave., Troy, N. Y.
1905	Meister, C. L		M. E., Atlantic Coast Line	Wilmington, N. C.
1895	Mellin, C. J		American Locomotive Co	Schenectady, N. Y.
1900	Mendenhall, C. M			2 Rector st., New York City.
1903	*Menzel, W. G.*	190	*S. M. P., Wisconsin Central*	*Fond du Lac, Wis.*
1892	Mertsheimer, F			Pittsburg, Kan.
1887	Michael, J. B.		M. M., Southern	Knoxville, Tenn.
1885	Millen, Thos		M. M., Metropolitan Street Ry.	106 W. 51st st., N. Y.
1889	*Miller, E. A*	180	*S. M. P., N. Y. C. & St. L.*	*Cleveland, Ohio.*
1890	Miller, Geo. A.		M. M., Florida East Coast.	St. Augustine, Fla.
1903	Miller, J. B		G. F., St. L. Southwestern of Texas	Waco, Tex.
1901	Miller, S. W			36 W. 5th st., Dunkirk, N. Y.
1906	Miller, Wm		Supt. M. P. & C. D., Western Maryland.	Union Bridge, Md.
1903	Miller, W. J.		M. M., St. L. Southwestern of Texas.	Tyler, Tex.
1903	Milliken, James.		S. M. P., Phila., Balt. & Washington	Wilmington, Del.
1893	Minshull, P. H		M. M., N. Y. O. & W.	Middletown, N. Y.
1892	Minto, H. M		M. M., Louisville & Nashville.	Mobile, Ala.
1888	Minton, A. B.		M. M., Mobile & Ohio	Jackson, Tenn.
1892	Mitchell, A. E		Mgr. Purchases & Supplies, N. Y. N. H. & H.	New Haven, Conn.
1903	Moir, William		G. M. M., Northern Pacific	So. Tacoma, Wash.
1898	Moler, A. L			Carl Junction, Mo.
1970	Moll, George		M. M., Philadelphia & Reading	Reading, Pa.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1901	Monahan, J. J.		M. M., Louisville & Nashville.	Paris, Tenn.
1890	Monkhouse, H.		Rome Loco. & Mach. Works.	Rome, N. Y.
1903	Monlaverde, F.		Paulista	Santos, Brazil.
1903	Monroe, M. S.		M. M., Chicago, Lake Shore & Eastern.	Chicago, Ill.
1907	Montgomery, Hugh		G. F., Central R. R. of N. J.	Jersey City, N. J.
1884	Montgomery, Wm		M. M., Central of N. J.	Lakehurst, N. J.
1890	Moore, J. H.		M. M., Erie	Rochester, N. Y.
1896	Moran, Robert		M. M., Louisville & Nashville.	Nashville, Tenn.
1907	Moran, W. F		M. M., Southern	Sheffield, Ala.
1901	Morgan, J. B.		G. M. M., Toledo & Ohio Central.	Bucyrus, Ohio.
1907	Moriarty, G. A		M. M., Erie	Port Jervis, N. Y.
1887	Morris, W. S			813 W. Berry st., Ft. Wayne, Ind.
1905	Morrison, J. R.		M. M., Inverness Ry. & Coal Co	Inverness, C. B., Can.
1906	Mowery, J. N		M. E., Lehigh Valley	So. Bethlehem, Pa.
1901	Muchnic, C. M.		American Locomotive Co	New York, N. Y.
1904	Mudd, G. W		M. M., Denver & Rio Grande	Alamosa, Colo.
1899	*Muhlfeld, J. E.*	1843	*G. S. M. P., Baltimore & Ohio*	*Baltimore, Md.*
1905	Mullen, D. J		M. M., C. C. C. & St. L	Mt. Carmel, Ill.
1904	Murphy, J. H		M. M., Cin., New Orleans & Tex. Pac.	Ludlow, Ky.
1890	Murphy, P. H		Murphy Car Roof Co	East St. Louis, Ill.
1905	Murray, W. H.		G. F., Atchison, Topeka & Santa Fe.	Winslow, Ariz.
1903	Murrian, W. S.		M. M., Southern	Alexandria, Va.
1904	Needham, E. F.		M. M., Wabash	Springfield, Ill.
1905	Nelson, E. D		E. of T., Pennsylvania.	Altoona, Pa.
1894	Nettleton, W. A.		G. S. M. P., St. Louis & San Francisco.	St. Louis, Mo.
1898	Neubert, G. T		M. M., Kansas City Belt	Kansas City, Mo.
1892	Neuffer, John G		A. S. M., Illinois Central	Chicago, Ill.
1901	Neville, John.			Comey, Michoacan, Mex.
1896	Neward, F. H.		M. M., Pontiac, Ox. & Northern	Pontiac, Mich.
1906	Newhouse, J. F.		M. M., Ken. & Ind. Bridge & R. R	Louisville, Ky.
1875	Noble, L. C			Fisher Bldg., Chicago, Ill.
1902	Nolan, J. C		M. M., Arkansas Southern.	Ruston, La.
1899	Nolan, J. P		M. M., Morgan's L. & T. R. R. & S. S. Co.	Algiers, La.
1906	Noyes, C. T		S. S., Southern Pacific	Sacramento, Cal.
1902	Nutt, Geo. B.		L. S., Egyptian State Ry	Cairo, Egypt.
1896	Nuttall, W. H.		M. M., Manistee & Northeastern	Manistee, Mich.
1905	O'Beirne, P.		S. M., Toluca, Marquette & Northern.	Toluca, Ill.
1903	O'Hearne, J. E.		M. M., Wheeling & Lake Erie.	Norwalk, Ohio.
1890	O'Herin, Wm		S. M., Mo., Kan. & Tex.	Parsons, Kan.
1895	O'Leary, D		M. M., Pacific Coast	Seattle, Wash.
1905	Oplinger, J. W		S. M. P., Atlantic Coast Line.	Savannah, Ga.
1901	Ord, C. R.		M. M., Canadian Pacific.	McAdam Jct., N. B., Can.
1907	Oviatt, H. C		M. M., N. Y., New Haven & Hartford	New Haven, Conn.
1906	Owens, W. H.		M. M., Southern	Manchester, Va.
1901	Parish, LeGrand.		S. M. P., Lake Shore & Mich. Southern	Cleveland, Ohio.
1900	Parker, M. B.		M. M., Rockwood & Tenn. River.	Rock Run, Ala.
1905	Parks, Geo. E.		M. M., Michigan Central	Jackson, Mich.
1901	Park, S. T		S. M. P., Chicago & Eastern Illinois	Danville, Ill.
1903	Park, P. D.		M. M., Reid Newfoundland Co.'s	Whitbourne, N. F.
1903	Passmore, H. E.		M. M., Toledo & Ohio Central	Kenton, Ohio.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1879	Patterson, J. S			Galena Signal Oil Co., Cincinnati, Ohio.
1904	Patterson, Robt		M. M., Rio Grande Southern	Ridgway, Colo.
1903	Paul, W. M		M. M., Gal., Houston & Henderson.	Galveston, Tex.
1891	Paxton, Thos		S. M. P., El Paso & South Western.	Douglas, Ariz.
1904	Pearce, J. S		M. M., Norfolk & Western	Portsmouth, Ohio.
1903	Pearsall, D. M.		M. M., Atlantic Coast Line	Montgomery, Ala.
1899	Pearse, H.		Buenos Ayres & Rosario, La Quinta,	Rosario de Santa Fe, Arg. Rep., S. A.
1887	*Peck, Peter H*	*75*	*M. M., C. & W. I. and Belt*	*Chicago, Ill.*
1901	Pengelly, J. H.			City of Mexico, Mex.
1899	Pennington, J. H			27 States ave., Atlantic City, N. J.
1897	Peyton, H. T.		M. M., Atchison, Topeka & Santa Fe	Wellington, Kan.
1907	Pfafflin, Louis		M. M., Indianapolis Union	Indianapolis, Ind.
1907	Pfahler, F. P.		M. E., Wheeling & Lake Erie.	Norwalk, Ohio.
1897	Pflager, H. M		Commonwealth Steel Co	St. Louis, Mo.
1900	Phillips, C		M. M., New Orleans & Northeastern.	Meridian, Miss.
1906	Phipps, S		M. M., Canadian Pacific.	Revelstroke, B. C.
1903	Piccioli, J.		M. M., Colorado & Wyoming	Minnequa, Colo.
1905	Pierce, F. M		M. M., Hawkinsville & Florida Sou.	Pitts, Ga.
1902	Pilcher, J. A		M. E., Norfolk & Western.	Roanoke, Va.
1904	Pinheiro, Antonio.		Mogyana R. R.	Campinos, Brazil, S. A.
1901	Place, F. E		Buda Foundry & Machine Co.	Harvey, Ill.
1900	Plank, P. D.		M. M., Louisville, Hend. & St. Louis	Cloverport, Ky.
1903	Platt, J. G			Meadville, Pa.
1881	Player, John			319 Franklin ave., River Forest, Ill.
1897	Pollitt, Harry		Great Central	Fernlea, Altricham, Cheshire, Eng.
1906	Poole, A. J.		M. M., Seaboard Air Line	Atlanta, Ga.
1900	Post, W. F.		Watkins Foundry & Machine Co.	Hattiesburg, Miss.
1897	Potton, J.		M. M., Texas & Pacific	Big Springs, Tex.
1905	Powell, V. U.		M. M., Illinois Central	Mattoon, Ill.
1906	Powers, M. J		M. M., Delaware & Hudson	Carbondale, Pa.
1903	Pratt, E. W.		M. M., Chicago & North-Western	Missouri Valley, Iowa.
1907	Prendergast, A. P.		M. M., Baltimore & Ohio.	Baltimore, Md.
1907	Prendergast, J. L.		M. M., Baltimore & Ohio.	Glenwood, Pa.
1903	Prendergast, W. H.		M. M., Central of Georgia	Savannah, Ga.
1891	Prescott, C. H.		M. M., Spokane International.	Spokane, Wash.
1905	Preston, Robert		M. M., Canadian Pacific.	Toronto Jct., Toronto, Can.
1900	Prince, S. F., Jr			122 W. 49th st., New York, N. Y.
1905	Purdy, Jos. B		M. M., Hilo	Hilo, Hawaii.
1890	Purves, T. B., Jr		S. M. P., Denver & Rio Grande	Denver, Colo.
1888	*Quayle, Robert*	1307	*S. M. P. & M., Chicago & N.-W.*	*Chicago, Ill.*
1895	Quereau, C. H.		S. E. E., N. Y. C. & H. R. R. R	New York, N. Y.
1890	Randolph, L. S.		Virginia Polytechnic Institute	Blacksburg, Va.
1903	Records, J. W.		M. M., St. L., Rocky Mtn. & Pacific	Raton, N. M.
1901	Redding, D. J		M. M., Pittsburgh & Lake Erie	McKee's Rocks, Pa.
1904	Reeves, P. H.		M. M., Baltimore & Ohio.	Chillicothe, Ohio.
1902	Reid, W. L		American Locomotive Co	Schenectady, N. Y.
1883	Renshaw, W		S. M., Illinois Central.	Chicago, Ill.
1892	Rettew, C. E.		D. & H. Co	Carbondale, Pa.
1896	Reynolds, O. H.		Bethlehem Steel Co	New York City.
1899	Rhodes, L. B.		M. M., Georgia Southern & Florida.	Macon, Ga.
1905	Rice, J. H		M. M., De Queen & Eastern	De Queen, Ark.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1907	**Richardson**, L. A		M. M., Chicago, Rock Island & Pacific	Trenton, Mo.
1901	**Richmond**, W. H		M. M., Lake Superior & Ishpeming	Marquette, Mich.
1903	**Rickard**, W. W			Tucson, Ariz.
1907	**Rieckman**, W. H		A. M. M., Boston & Maine	Mechanicsville, N. Y.
1894	**Riley**, George N		M. M., McKeesport Connecting	Pittsburgh, Pa.
1902	**Robb**, J. M		M. M., Chicago Great Western	Chicago, Ill.
1901	**Robb**, W. D		S. M. P., Grand Trunk	Montreal, P. Q.
1901	**Roberts**, Jos		M. M., Union Pacific	Armstrong, Kan.
1896	**Roberts**, J. W			1237 Bellefontaine st., Indianapolis, Ind.
1891	**Roberts**, Mord			Little Rock, Ark.
1895	**Robinson**, Frank		Robinson Co	Boston, Mass.
1903	**Robinson**, Maynard		M. M., Gulf, Colo. & Santa Fe	Silsbee, Tex.
1906	**Roesch**, F. P		M. M., Southern	Spencer, N. C.
1896	**Rogers**, M. J			1008 West 24th st., Kansas City, Mo.
1903	**Rogers**, R. H		M. M., N. Y. N. H. & Hartford	Boston, Mass.
1900	**Roope**, Thos		S. M. P., Chicago, Burl. & Quincy	Lincoln, Neb.
1896	**Rosing**, W. H. V		M. E., Missouri Pacific	St. Louis, Mo.
1895	**Royal**, C. B			151 Franklin ave., Oak Park, Ill.
1898	**Rumney**, T		M. S., Erie	Meadville, Pa.
1896	**Rusch**, Peter C		M. M., Buffalo, Rochester & Pittsburgh	Bradford, Pa.
1907	**Russell**, A. C		M. M., Inter-California	Hanlon Jct., Cal.
1907	**Russell**, W. B		Asst. Supt. Apprentices, N. Y. C. Lines	New York City.
1903	**Russell**, W. H		M. M., Southern Pacific	Oakland, Cal.
1893	**Ryan**, E		M. M., Gal., Houston & San Antonio	San Antonio, Tex.
1891	**Ryan**, J. J		S. M. P., Southern Pacific	Houston, Tex.
1892	**Ryan**, Patrick		M. M., Louisville & Nashville	Russellville, Ky.
1892	**Sague**, J. E		Public Service Commission, 2d District	Albany, N. Y.
1906	**Sakuma**, T		S. M. P., Kinshui	Moji, Japan.
1887	**Sample**, N. W		Baldwin Locomotive Works	Philadelphia, Pa.
1896	*Sanderson, R. P. C.*	*342*	*S. M. P., Virginian Ry*	*Norfolk, Va.*
1903	*Scheffer, F. H*	*234*	*S. M. P., Nashville, Chatt. & St. Louis*	*Nashville, Tenn.*
1903	**Schilling**, R. P		M. M., Del., Lack. & Western	Utica, N. Y.
1905	**Schlacks**, W. J			Old Colony Bldg., Chicago, Ill.
1904	**Schlafge**, Wm		M. M., Erie	Jersey City, N. J.
1901	**Seabrook**, C. H		M. M., St. Louis Southwestern	Pine Bluff, Ark.
1907	**Sechrist**, T. O		M. M., Cin., N. O. & Texas Pacific	Chattanooga, Tenn.
1907	**Seddon**, C. W		S. M. P., Duluth, Missabe & Northern	Proctor (St. Louis Co.), Minn.
1875	**Sedgwick**, E. V			Galena Signal-Oil Co., Franklin, Pa.
1900	**Seidell**, G. W		Supt. Shops, Chicago, R. I. & Pacific	Silvis, Ill.
1900	**Seley**, C. A		M. E., Chicago, Rock Island & Pacific	Chicago, Ill.
1907	**Shaff**, C. D., Jr		M. M., N. Y. Central & Hudson River	Watertown, N. Y.
1906	**Shea**, R. T		Insp. Tools and Machy., N. Y. C. Lines	New York City.
1903	**Sheahan**, J. F		M. M., Southern	Columbia, S. C.
1907	**Shelaberger**, John		M. M., Southern Pacific Co	Bakersfield, Cal.
1899	**Shepard**, L. A		Atha Steel Casting Co	Newark, N. J.
1903	**Shepard**, Samuel		M. M., Minn., St. Paul & Sault Ste. Marie	Gladstone, Mich.
1905	**Shields**, A		M. M., Canadian Northern	Winnipeg, Man., Can.
1906	**Shields**, H. C		Supt., Lehigh & New England	Pen Argyl, Pa.
1904	**Shoemaker**, H		M. M., Del., Lack. & Western	Scranton, Pa.
1906	**Shreve**, W. J		M. M., Minn. & Rainy River	Deer River, Minn.
1883	**Sinclair, Angus**			136 Broadway, New York City.
1900	**Singer, Frank**		M. M., Florence & Cripple Creek	Colorado Springs, Colo.
1892	**Sinnott**, W		M. M., Baltimore & Ohio	58th st., Phila., Pa.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1889	Skinner, H. M. C			579 Durfee st., Fall River, Mass.
1893	Slater, Frank		M. M., Chicago & North-Western	Escanaba, Mich.
1894	Slayton, C. E		M. M., Deepwater	Page, W. Va.
1900	Slayton, F. T		M. M., St. Joseph & Grand Island	St. Joseph, Mo.
1889	*Small, H. J.*	1170	*G. S. M. P., Southern Pacific*	*Oakland, Cal.*
1903	Smith, C. B		M. E., Boston & Maine	Boston, Mass.
1900	Smith, D. A.		M. M., Boston & Maine	East Somerville, Mass.
1904	Smith, E. J		M. M., Atlantic Coast Line	Florence, S. C.
1893	Smith, F. B.			Indianapolis, Ind.
1896	Smith, F. C.		American Locomotive Co	Providence, R. I.
1900	Smith, F. J		M. M., B. & O. S.-W	Washington, Ind.
1892	Smith, John L.		G. F., Pitts., Shawmut & Northern	St. Marys, Pa.
1900	Smith, L. L		M. M., Chicago & Milwaukee Electric	Highwood, Ill.
1907	Smith, M. W		M. M., Tampa & Jacksonville	Gainesville, Fla.
1899	Smith, R. D		Mech. Expert, N. Y. Central Lines	Chicago, Ill.
1905	*Smith, R. E*	538	*A. G. M., Atlantic Coast Line*	*Wilmington, N. C.*
1902	Smith, Wm		Lyman Mfg. Co.	East Buffalo, N. Y.
1869	Smith, W. T		M. M., Chesapeake & Ohio	Covington, Ky.
1903	Smitham, N. L.		M. M., Texas Central	Walnut Springs, Tex.
1906	Smock, F. A		G. F., Penna. R. R.	Meadows, N. J.
1891	Soule, R. H			1571 Beacon st., Brookline, Mass.
1907	Sprowl, N. E.		M. M., Atlantic Coast Line	Savannah, Ga.
1901	Squire, W. C.		Westinghouse Air Brake Co	Wilmerding, Pa.
1898	Stansbury, C. M.		M. M., Western Pacific	Stockton, Cal.
1898	Stevenson, C. E		S. M. P., Mogyana	Campinos, San Paulo, Brasil, S. A.
1903	Stewart, A.		M. S., Southern	Washington, D. C.
1906	Stewart, A. F		M. M., Chesapeake & Ohio	Clifton Forge, Va.
1906	Stewart, C. J.		M. M., Central New England	Hartford, Conn.
1907	Stewart, C. M		M. M., Philadelphia & Reading	Tamaqua, Pa.
1900	Stewart, M. D.		Fitz-Hugh Luther Co.	Chicago, Ill.
1885	Stewart, O.		S. M. P., Bangor & Aroostook	Oldtown, Me.
1905	Stewart, T. R		M. M., Baltimore & Ohio	Cumberland, Md.
1890	Stillman, H.		E. of T., Southern Pacific	Oakland, Cal.
1896	Stocks, W. H			5851 Indiana ave., Chicago, Ill.
1905	Struthers, Alex		M. M., Denver, Northwestern & Pacific	Denver, Colo.
1890	Studer, A. L			Iola, Kan.
1901	Sullivan, J. J.		M. M., Louisville & Nashville	New Decatur, Ala.
1891	Summerskill, T. A			St. Albans, Vt.
1892	Sumner, Eben T.		M. M., Boston & Maine	E. Cambridge, Mass.
1899	Suzuki, S.		S. M. P., Kinshui	Moji, Japan.
1901	Swoyer, H.		Rogers Locomotive Works	Paterson, N. J.
1899	Symington, T. H			St. Paul Bldg., Baltimore, Md.
1892	Symons, W. E.		Pioneer Cast Steel Truck Co.	Postal Telegraph Bldg., Chicago, Ill.
1883	Tandy, H.		Supt., Canadian Locomotive Works	Kingston, Ont., Can.
1896	Tawse, Robert		Ann Arbor	Owosso, Mich.
1893	Taylor, C. M			La Junta, Colo.
1901	Taylor, H. D.		S. M. P. & R. E., Phila. & Reading	Reading, Pa.
1893	Taylor, Wm. H.		M. M., N. Y., Susq. & Western	Stroudsburg, Pa.
1905	Taylor, W. M		M. M., Thornton & Alexandria	Thornton, Ark.
1903	Teat, W. F.		M. M., Atlanta, Knox. & Northern	Blue Ridge, Ga.
1905	Temple, C. H.		M. M., Canadian Pacific	Winnipeg, Man.
1904	Terrill, C. H.		M. M., Chesapeake & Ohio	Huntington, W. Va.
1904	Thomas, E.		S. M. P., Andino Ry	Rio Cuarto, Arg. Rep., S. A.
1891	Thomas, H. T		M. M., Detroit & Mackinac	East Tawas, Mich.

NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
ıomas, P. G		M. M., Central R. R. of N. J	Ashley, Pa.
ıomas, J. J., Jr		M. M., Atlantic Coast Line	So. Rocky Mtn., N. C.
ıomas, W. H			4230 Spruce st., Philadelphia, Pa.
ıomas, W. J		Christobal Shops	Canal Zone.
ıompson, C. A.			Morris Park, Long Island, N. Y.
ıompson, E. B.		A. S. M. P., Chicago & North-Western.	Chicago, Ill.
ıompson, Geo.		S. M. P., Denver, Northwestern & Pac.	Denver, Colo.
ıompson, W. O		M. C. B., N. Y. Central & H. R. R. R	Buffalo, N. Y.
ıompson, W. T			38 Anderson place, Buffalo, N. Y.
ıornton, Chas. J		L. S., United Rys. of Havana	Havana, Cuba.
ıow, Wm		Government	Eveleigh, N. S. W.
nker, J. H		M. M., Illinois Central	Mounds, Ill.
›dd, A. B		M. M., Southern California	Richmond, Cal.
›dd, Louis C.		M. M., Boston & Maine	Charlestown, Mass.
›llerton, W. J.		A. G. S. M. P., Chicago, R. I. & Pacific.	Chicago, Ill.
›ltz, Max.		Manistee & Grand Rapids	Manistee, Mich.
›nge, John		M. M., Minneapolis & St. Louis	Minneapolis, Minn.
›nge, Thos. J		S. M. P. & R. S., Santa Fe Central	Estancia, N. M.
›rrey, F. A		S. M. P., Chicago, Bur. & Quincy	Chicago, Ill.
·acy, W. L		M. M., Louisville & Nashville.	Louisville, Ky.
·aver, W. H		Chicago Pneumatic Tool Co	Chicago, Ill.
·egelles, Henry.		Care Norton, Megaw & Co.,	Rio De Janeiro, Brazil.
ıggle, S. R		S. M. P., Houston & Texas Central.	Houston, Tex.
ıma, Frank.		M. M., Erie	Buffalo, N. Y.
ırnbull, A. G		A. M. S., Erie	Meadville, Pa.
ırner, A.		M. M., Lehigh Valley	South Easton, Pa.
ırner, Calvin G		M. M., Phila., Balt. & Washington	Wilmington, Del.
ırner, Chas. E			Rochester, N. Y.
ırner, J. A		M. M., C. St. P. M. & O. Ry.	Itasca, Minn.
ırner, J. S.			24 Broad st., N. Y. City.
ırner, L. H.	*189*	*S. M. P., Pittsburg & Lake Erie*	*Pittsburg, Pa.*
ırtle, J. A		M. M., Union Pacific	Omaha, Neb.
ldenberg, C. E.		A. S. M. P., Swedish Government	Boden, Sweden.
n Alstyne, D.		American Locomotive Co	Dunkirk, N. Y.
naman, C. D.		M. M., Florida East Coast.	St. Augustine, Fla.
n Buskirk, H. C.	*172*	*S. M. P., Colorado & Southern.*	*Denver, Colo.*
n Cleve, J. R		M. M., Alaska Central	Seward, Alaska.
n Doren, G. L.		S. S., Central R. R. of New Jersey	Roselle Park, N. J.
n Ripper, D. F.		M. M., Erie	Avon, N. Y.
ıclain, Samuel M.		Baldwin Locomotive Works	Philadelphia, Pa.
ughan, H. H.	*550*	*Asst. to V. P., Canadian Pacific.*	*Montreal, Can.*
·net, C. C.		S. M. P., Western Ry. of Havana	Havana, Cuba.
gt, A. S.		M. E., Pennsylvania.	Altoona, Pa.
ddington, John.		Central Northern R. R	S. Cristobal, Arg. Rep., S. A.
gstaff, George		S. B., New York Central Lines.	Buffalo. N. Y.
hlen, John		M. M., Montpelier & Wells River.	Montpelier, Vt.
itt, A. M.			320 5th ave., New York City, N. Y.
lker, Henry E.		Buenos Aires Great Southern	Buenos Ayres, Arg. Rep., S. A.
llace, W. G.	*58*	*S. M. P., Detroit, Toledo & Ironton.*	*Jackson, Ohio.*
llis, Phillip.			50 W. 45th st., New York City.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1900	*Walsh, F. O.*	32	*M. M., A. & W. P. & W. Ry. of Ala*	*Montgomery, Ala.*
1903	Walsh, J. F.		S. M. P., Chesapeake & Ohio	Richmond, Va.
1874	Walsh, Thos		M. M., Louisville & Nashville.	Howell, Ind.
1902	Walsh, W. C		M. M., Missouri Pacific	Ft. Scott, Kan.
1896	Walton, E. A.		S. M. P., N. Y. C. & H. R. R. R.	Avis, Pa.
1883	Warren, Beriah.			1619 Pennsylvania ave., St. Louis, M
1882	Warren, W. B.		Supt. St. L., Troy & Eastern	St. Louis, Mo.
1903	Waters, J. J.		S. M. D., Mex. International	Ciudad Porfirio Diaz, Me
1906	Watkins, W. H.		M. M., Illinois Central	Water Valley, Miss.
1902	Watson, Samuel		M. M., N. Y. C. & H. R. R. R.	W. Albany, N. Y.
1904	Watters, J. H		A. M. M., Georgia.	Augusta, Ga.
1883	Watts, Amos H.		M. M., Cincinnati Northern.	Van Wert, Ohio.
1907	Webb, E. R.		M. M., Mich. Central	Michigan City, Ind.
1907	Weisgerber, E. L		M. M., Baltimore & Ohio.	Newark, Ohio.
1900	Welch, C. H		M. M., Midland Valley.	Excelsior, Ark.
1906	Wells, M. E		A. M. M., Wheeling & Lake Erie	Massillon, Ohio.
1880	*West, G. W*	167	*S. M. P., N. Y. O. & W*	*Middletown, N. Y.*
1899	Westmark, H. O.			164 So. River st., Aurora, Il
1903	Whale, George		London & Northwestern	Crewe, England.
1907	White, Alfred		S. M., Copper River & North Western	Katalla, Alaska.
1885	White, A. M		American Locomotive Co	Manchester, N. H.
1894	White, E. T.		S. M. P., Baltimore & Ohio.	Mt. Clare, Baltimore, Mo
1901	White, W.			225 Ry. Exchange Bldg., Chicago, Il
1898	Whyte, F. M		C. M. E., N. Y. Central Lines.	New York City.
1905	Wickhorst, M. H.		E. of T., Chicago, Burl. & Quincy	Aurora, Ill.
1899	Wiest, E. N.		M. M., Manistee & North-Eastern.	Manistee, Mich.
1894	Wiggin, Chas. H.		S. M. P., Boston & Maine.	Boston, Mass.
1878	Wightman, D. A.			Warren, R. I.
1900	Wilbur, I. N		M. M., Chicago, Burlington & Quincy.	Hannibal, Mo.
1891	Wilcox, W. J.		M. M., Mexican Central	Chihuahua, Mex.
1901	Wildin, G. W.		M. S., N. Y., New Haven & Hartford.	New Haven, Conn.
1896	Williams, Alfred		Paulista	Paulista, Brazil, S. A.
1905	Williams, C. R		G. M. M., Buffalo & Susquehanna	Galeton, Pa.
1891	Williams, E. A			New York, N. Y.
1903	Williams, F. W.			Lyndhurst, N. J.
1905	Willius, Gustav, Jr.		M. E., Great Northern.	St. Paul, Minn.
1905	Wilson, Charles.		M. M., Lehigh Valley	Wilkesbarre, Pa.
1906	Wilson, D. H., Jr.		Elec. Engr., Erie.	Meadville, Pa.
1887	Wilson, G. F.		P. A., Del., Lack. & Western.	New York City.
1901	Wilson, W. H		S. M. P., Buffalo, Roch. & Pittsburg.	Du Bois, Pa.
1900	Wirt, G.		M. M., C. C. C. & St. L	Delaware, Ohio.
1900	Withers, A. B.		321 Chatham Ave.	Rock Hill, S. C.
1907	Witherspoon, David.		G. F., Central R. R. of N. J.	Bayonne, N. J.
1906	Woodbridge, H. C		M. M., Buffalo, Roch. & Pittsburgh	E. Salamanca, N. Y.
1903	Woodruff, S. N		M. M., Minn., St. P. & Sault Ste. Marie.	Enderlin, N. D.
1903	Worsdell, Wilson		C. M. E., North-Eastern	Gateshead-on-Tyne, Eng
1901	Wright, R. V.		American Engineer.	285 N. 20th st., E. Orange, N. J
1907	Wyman, R. L.		M. M., Lehigh & New England	Pen Argyl, Pa.
1907	Yamamoto, Y.		M. E., South Manchurian	Tairen, Manchuria.
1903	Yergens, W. F.		M. M., Erie	Huntington, Ind.
1896	Yohn, A. E		M. M., H. & B. T. Mtn	Saxton, Pa.
1899	York, C. C		B. A. & Pacific	Estacion Junin, Buenos Ayres, Arg. Rep., S. A
1907	Yoshino, M		S. M. P., South Manchurian.	Tairen, Manchuria.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1902	Young, C. B		M. E., Chicago, Burlington & Quincy	Chicago, Ill.
1905	Young, R. R		M. M., Atlantic Coast Line	Waycross, Ga.
1907	Zang, P. C		M. M., N. Y., New Haven & Hartford	Providence, R. I.
1898	Zerbee, F. J.		M. M., C. C. C. & St. L	Bellefontaine, Ohio.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1893	Baker, Geo. H	227 Monroe st., Brooklyn, N. Y.
1898	Basford, G. M	Amer. Loco. Co., 111 Broadway, New York City.
1898	Bates, E. C	Lock Box 1544, Boston, Mass.
1907	Bell, J. Snowden	31 Nassau st., New York City.
1903	Casey, F. A	271 Franklin st., Boston, Mass.
1896	Fowler, Geo. L	53 Broadway, New York City.
1907	Fry, Lawford, H	110 Cannon st., London, E. C., Eng.
1895	Goss, W. F. M	Purdue University, Lafayette, Ind.
1889	Hill, John A	80 Munn ave., E. Orange, N. J.
1904	Hodgins, George	136 Liberty st., New York City.
1899	Kneass, Strickland L	Wm. Sellers Co., Ltd., Philada., Pa.
1901	Lane, F. W	*Railway Age*, Monadnock Bldg., Chicago, Ill.
1904	Lanza, Gaetano	Mass. Inst. of Technology, Boston, Mass.
1901	Player, John	American Loco. Co., Brooks Works, Dunkirk, N. Y.
1889	Pomeroy, L. R	General Electric Co., 44 Broad st., New York City.
1899	Smart, R. A	Westinghouse E. & M. Co., Pittsburgh, Pa.
1882	Smith, W. A	Manhattan Bldg., Chicago, Ill.
1899	Street, Clement F	Westinghouse E. & M. Co., Pittsburgh, Pa.
1903	Taylor, Jos. W	390 Old Colony Bldg., Chicago, Ill.

HONORARY MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1885	Becker, Andrew		New Decatur, Ala.
1879	Cooke, Allen		Danville, Ill.
1869	Coolidge, G. A.		Barnard ave., Watertown, Mass.
1870	Cooper, H. L.		Chesterton, Ind.
1876	Cory, Chas. H		Lima, Ohio.
1895	Coster, E. L.	Residence, Irvington-on-Hudson.	Broad Exchange Bldg., 25 Broad st., N. Y. City.
1870	Divine, J. F.	Atlantic Coast Line	Wilmington, N. C.
1881	Eastman, A. G		Sutton, Que.
1869	Elliott, Henry.		East St. Louis, Ill.
1881	Ennis, W. C.		Passaic, N. J.
1871	Forney, M. N.		501 5th ave., New York City.
1872	Foss, J. M	Central Vermont.	St. Albans, Vt.
1885	Galloway, A.	C. H. & D.	Cincinnati, Ohio.
1871	Hewitt, John.		1323 So. Jefferson st., St. Louis, Mo.
1874	Jeffery, E. T	Denver & Rio Grande	Denver, Colo.
1868	Johan, Jacob.		Springfield, Ill.
1868	Kinsey, J. I.	Lehigh Valley	Easton, Pa.
1878	Maglenn, Jas	Seaboard Air Line.	Raleigh, N. C.
1869	McKenna, John		2005 N. Alabama ave., Indianapolis, Ind.
1871	Miles, F. B.	Bement & Miles	Philadelphia, Pa.
1885	Paxson, L. B.	Philadelphia & Reading.	Reading, Pa.
1872	Philbric, J. W		Waterville, Me.
1878	Pilsbury, Amos.		Portland, Me.
1874	Place, T. W.		Waterloo, Iowa.
1887	Rhodes, Godfrey W		Westhaugh, Pontefract, Yorkshire, England.
1869	Richards, George		14 Auburn st., Roxbury, Mass.
1870	Robinson, W. A		Hamilton, Ont.
1874	Schlacks, Henry		Denver, Colo.
1869	Sellers, Morris		Western Union Bldg., Chicago, Ill.
1869	Setchel, J. H		Cuba, N. Y.
1891	Sheer, J. M		514 7th st., East St. Louis, Ill.
1888	Sheppard, F. L	Pennsylvania.	Altoona, Pa.
1868	Sprague, H. N.		Jamestown, N. Y.
1875	Strode, Jas.		Elmira, N. Y.
1883	Sullivan, A. W	Illinois Central	Chicago, Ill.
1869	Thompson, John		51 Lakewood Road, Newton Highlands, Mass.
1870	Towne, H. A		54 S. 3d st., Minneapolis, Minn.
1883	Twombly, F. M		18 Farquhar st., Rosindale, Mass.
1868	Wells, Reuben.		Paterson, N. J.

PROCEEDINGS.

WEDNESDAY'S SESSION.

JUNE 12.

President J. F. Deems called the meeting to order at 9:45 o'clock, and said:

I wish to extend an invitation to the past presidents of both associations, the president of the Master Car Builders' Association, and the members of the Executive Committee of the American Railway Master Mechanics' Association, to take place on the platform.

The Divine blessing was then offered by the Rev. Newton W. Cadwell, D.D., pastor of the Olivet Presbyterian Church of Atlantic City.

THE PRESIDENT: We have with us this morning Mayor F. P. Stoy, of Atlantic City, who has kindly consented to make a few remarks, either welcoming or regretting our presence in Atlantic City; perhaps he can better decide the latter part of the proposition when we have gone. I take pleasure in introducing Mayor Stoy.

MAYOR STOY: Mr. President, Ladies, Car Builders and Members of this Association: To get up so early in the morning and to follow the band prior to meeting such a large gathering of intellectual people is not a usual experience for a mayor; but I feel it an honor to be here this morning. Providence seems to have smiled upon you this morning in giving you such weather, because only yesterday it seemed to have hailed or snowed here. I assure you it is a great pleasure on this beautiful morning to

come here and bid you welcome, and to extend to you the freedom of the city for the second time.

I remember some of the incidents of last year, perhaps some of which your President referred to, and I want to say I have not regretted those moments I spent with you, although some of them were very strenuous.

We thank you, Mr. President and members, for coming again to Atlantic City. We feel it an honor and hope you will find as much pleasure here this time as you did last year. I assure you the weather shall be guided to the best of our ability, and I know the arrangements for your comfort are much better than last year, and I trust it will be good for you to be here, not only individually but collectively. I will not detain you, Mr. President, with further remarks other than to offer you again a hearty welcome to the freedom of the city. [Applause.]

THE PRESIDENT: I will call on Mr. A. M. Waitt to kindly respond to the address of welcome of Mayor Stoy.

MR. A. M. WAITT: Mr. Mayor, I had the pleasure, on behalf of the Association last year, of tendering you our thanks, and it is with pleasure, although unexpected by me until a moment ago, that I have the privilege of so doing again at this time. We surely appreciated the kindness extended to us last year. We appreciate all the kind words you have said on this occasion, and we will try to do justice to Atlantic City. We hope you will see that Atlantic City does credit to herself and gives us all the enjoyment and all the intellectual as well as other feasts that are possible. I thank you, Mr. Mayor, on behalf of the Association.

THE PRESIDENT: Members of the Master Mechanics' Association and our good brethren of the Supplymen's Association, Ladies and Gentlemen, friends and neighbors all: It may be a little presumptuous on my part, but I can not refrain on this occasion from indulging the pleasing vanity of addressing you as friends, because after more than a quarter of a century of railroad service and constant association with railroad people, it is my hope and my wish in my very heart of hearts, that I have at least some slight justification for considering some of these present as my friends; and it would seem that we may consistently consider ourselves neighbors in a literal sense, for we are really

and truly all neighbors, owing to the splendid railroad service in this land of ours — the most perfect railroad service, on the best equipped railroads, in the grandest, greatest country under God's blue sky. [Applause.] Did you ever stop to think that Omaha, or even Denver, is to-day, thanks to this railroad service, nearer to New York city than Philadelphia was in 1764, when Benjamin Franklin amused himself for three and a half days knitting stockings in a stage-coach while going from the Quaker City to New York to sail away to the other side in connection with some diplomatic service at the Court of St. James?

History makes no record of a development that is in any way a parallel to that which has taken place in connection with the railroads on this continent, and I dare assert here this morning, at this, its fortieth annual convention, that no organization, that no association as such, has done so much in this grand achievement as the one represented here to-day — The American Railway Master Mechanics' Association. [Applause.] The history of this association of earnest men is written in the progress of the nation, which of all nations the world is proud to call great. Throughout all time all great works have been effected by earnest men, few or many, brought together by a common object or a common impulse, whether conquest, colonization, political achievement, struggle for independence, or the defense of that which men hold most dear — this country, although young, bears upon its breast many medals and memorials to those who have devoted their lives to leadership in sanguinary strife. Monuments to military achievement are most common in the old world. Every land across the sea is dotted with those memorials which in their mute eloquence bear testimony to the fact that the world loves, honors and reveres the memory of those who have given their best for her glory, even though many of the causes for which they contended were never important, and have long since been forgotten. Where man has died for man is sacred ground, and while to those heroes we humbly pay the homage of our tears let us hope that the day of the military hero is passed, passed never to return, and that in his place is one who leads on and ever on in that greater development which stands for a future which means sublimer peace, a larger hope, greater happiness and a better humanity.

No war-bronzed veteran ever had deeper inspiration or greater cause for self-forgetful devotion than had the pioneers who bore the brunt of the early days of the development which this Association has so splendidly advanced. All the honors accorded to military achievement in the past will but illy compare with those which the future will gladly accord to the memory of the men who have given us that grander, that more useful development—transportation—without which to-day the world would be largely a waste. Our predecessors met in a small way, and singly, the problems which we and those who follow us must meet collectively and in a larger sense, and to solve which it will be necessary to form great combinations that must be harmonious, cohesive and permanent. It is no slight task to conceive and build a structure that will provide for the interchange of people, the mutation of ideas and the physical distribution of that which enters into man's every need. We are fortunate in that our fathers built so well; let us hope that those who follow can truly say the same of us; let us devote ourselves seriously to the problems of to-day; chief among which is to try to do as well the things that come to our hand as our predecessors did the smaller things that came to their hands.

A legacy has been bequeathed us by the generations that have gone before, a legacy for which all preparation has been made, a legacy of opportunity which looms large in the future and awaits with rich reward the man who is prepared — the man who is prepared. We have received; what shall we give? We have inherited; what shall we bequeath? What shall we leave to aid in solving the problems of the future, many of which may be much more perplexing than those we are called upon to solve to-day? We may work in brass and steel, and leave the most perfect mechanism; we may develop and improve and evolve methods and practices until nothing more can be desired; we may reach perfection in all these, in mechanism, structure and method, and yet our bequest be a failure and itself a burden unless we provide that which is paramount, which is over and above the sum total of all this, and for which even to-day events throughout the world are crying aloud — the man. A man prepared, experienced, earnest; hopeful and happy; consecrated to his work and ready to the hand of the future.

This, my friends, as I see it, constitutes our greatest opportunity, our most imperative, our most sacred duty. If the man is provided, the machine will cease to be a burden and methods will come forth as the buds at the kiss of spring. Our own future, and the hope of that larger future which lies beyond, depends on our efforts and our success in providing those who are to help us to-day, and upon whom at no distant day must fall our duties, our opportunities, our honors and our failures. Have we any greater, grander, more sublime obligation than this? Can we justify a pride in our life-work if we fail in this? If I can but bring to you this single message, if I can inspire you with this one thought, I am content. [Applause.]

Intermission.

The following members registered at this and following sessions:

Adams, T. E.
Addis, J. W.
Akans, George.
Aldcorn, Thomas.
Allen, C. W.
Allen, G. S.
Anthony, F. S.
Arp, W. C.
Arthur, C. G.

Barnes, F. P.
Barnum, M. K.
Basford, G. M.
Barton, T. F.
Bentley, H. T.
Berry, L. W.
Best, W. N.
Billingham, R. A.
Bingaman, C. A.
Boler, W. L.
Booth, J. S.
Bossinger, J. J.
Boyden, N. N.
Bradeen, J. O.
Branch, G. E.
Brangs, P. H.
Brazier, F. W.
Bronner, E. D.
Brown, David.
Brown, W. A.
Bryan, H. S.
Buchanan, A., Jr.
Bussing, G. H.
Butcher, G. W.

Caracristi, V. Z.
Casey, F. A.
Chamberlin, E.
Chambers, C. E.
Chambers, J. S.
Chester, W. E.
Chidley, Joseph.
Chisholm, J. E.
Christopher, J.
Clark, F. H.
Clark, J. H.
Cleaver, F. C.
Cockfield, William.
Cole, F. J.
Collier, L. L.
Collins, J. M.
Conners, J. J.
Connolly, J. J.
Cook, J. S.
Cooper, F. R.
Cooper, G. W.
Cory, C. H.
Cota, A. J.
Coutant, M. R.
Crawford, D. F.
Cromwell, O. C.
Cross, C. W.

Davis, D. E.
Davisson, F. E.
Deems, J. F.
Deeter, D. H.
Delaney, C. A.
Divine, J. F.
DeVoy, J. F.
Dickerson, S. K.
Diehr, C. P.
Dillon, S. J.
Dinan, Arthur.
Dolan, S. M.
Dooley, W. H.
Dorsey, J. P.
Dow, G. N.
Dunn, A. J.

Elliott, J. B.

Ellis, J. J.
Emerson, H.
Enright, J. F.
Ettinger, R. L.
Edmonds, G. S.
Edmondson, T. A.
Elden, Edward.
Ennis, W. C.

Feeley, T. M.
Ferguson, G. A.
Fetner, W. H.
Fildes, Thomas.
Fitzmorris, James.
Flavin, J. T.
Flory, B. P.
Fogg, J. W.
Forney, M. N.
Forsyth, William.
Fowler, G. L.
Fowler, W. E.
Franey, M. D.
Fraps, J. C.
Fraser, Thomas.
French, G. W.
Fries, A. J.
Fry, L. H.
Fuller, C. E.
Fulmor, J. H.

Gaines, F. F.
Gairns, A. H.
Gannon, J. B.
Garstang, William.
Gauthier, Jesse.
Gentry, T. W.
Gill, John.
Gillis, H. A.
Gilbert, F. M.
Gilmour, George.
Glass, J. C.
Goodrich, Max.
Gordon, H. D.
Gould, J. E.
Graham, Charles.
Gurry, George.

Hainen, J.
Hair, John.
Harrigan, P. J.
Harris, C. M.
Harrison, F. J.
Haritgan, B.
Haselton, G. H.
Haskell, B.
Hawkins, B. H.
Hayward, H. S.
Hedley, F.
Hennessey, T. J.
Herr, E. E.
Herr, E. M.
Hibbard, H. Wade.
Hickey, P. J.
Higgins, S.
Hildreth, F. F.
Hill, John.
Hill, W. H.
Hinckley, A. C.
Hocking, James.
Hodges, A. H.
Hodgins, George S.
Hogan, C. H.
Holtz, David.
Horsey, A. W.
Howard, John.
Hubbell, I. C.
Humphrey, A. L.
Hunt, H. B.
Hunter, G. S.
Hunter, H. S.

Irwin, J. E.

Joughins, G. R.

Kaderly, W. F.
Keegan, J. E.
Kells, Willard.
Kendig, R. B.
Kapp, W. F.
Kastlin, Jacob.
Kellogg, W. L.
Kilpatrick, J. B.
Kilpatrick, R. F.
Kinney, W. H.
Kirkpatrick, James.
Kneass, S. L.
Kyle, C.

Lane, F. W.
Latta, H. P.
Leach, H. L.
Leach, W. B.
Lewis, W. H.
Lonergan, P. T.

McArthur, F. A.
McCarthy, M. J.
McCuen, J. P.
McGee, G. S.
McHaffie, A. B.
McIntosh, William.
McKeen, W. R., Jr.
McKinsey, C. R.
McNulty, F. M.
McRae, J. A.
MacBain, D. R.
Macbeth, H. A.
Mackenzie, John.
Magarvey, J. R.
Maher, P.
Malthaner, W.
Manchester, A. E.
Manning, J. H.
Mannion, T. D.
Maver, A. A.
Meister, C. L.
Mellin, C. J.
Menzel, W. G.
Michael, J. B.
Millar, E. T.
Miller, E. A.
Miller, G. A.
Miller, William.
Millican, S.
Minshull, P. H.
Mitchell, A. E.
Mill, George.
Montgomery, William.

Moran, W. F.
Murphy, J. H.
Murrian, W. S.

Nelson, E. D.
Neubert, G. T.
Neuffer, J. G.
Newhouse, J. F.
Niland, William.
Noble, L. C.

O'Hearne, J. E.
O'Leary, D.
Ord, C. R.
Oviatt, H. C.
Owens, W. H.

Parish, L. G.
Parks, S. T.
Passmore, H. E.
Patterson, J. S.
Paul, W. M.
Pearce, J. S.
Peck, P. H.
Pflager, H. M.
Phillips, C.
Pilcher, J. A.
Platt, J. G.
Player, John.
Pomeroy, L. R.
Powers, M. J.
Pratt, E. W.
Prendergast, A. P.
Prendergast, J. P.
Preston, Robert.

Redding, D. J.
Reid, W. L.
Rettew, C. E.
Reynolds, O. H.
Rhodes, L. B.
Rieckmann, W. H.
Riley, G. N.
Rink, G. W.
Robb, J. M.
Robinson, Frank.
Roesch, F. P.
Rogers, R. H.
Roope, Thomas.
Russell, W. B.
Ryan, J. J.

Sague, J. E.
Schaff, C. D.
Scheffer, F. H.
Schlacks, Henry.
Seddon, C. W.
Sedgwick, E. V.
Seidell, G. W.
Seley, C. A.
Setchel, J. H.
Shepard, L. A.
Shoemaker, H.
Shreve, W. J.
Sinclair, Angus.
Sinnott, W.
Smith, C. B.
Smith, D. A.
Smith, G. W.
Smith, R. D.
Smith, W. A.
Smith, W. T.
Smith, M. W.
Smock, F. A.
Sprowl, N. E.
Stewart, A.
Stewart, A. F.
Stewart, C. J.
Stewart, O.
Stewart, T. R.
Stiffey, S. S.
Stocks, W. H.
Street, C. F.
Stuart, C. M.
Sumner, E. T.
Swoyer, H.
Symington, T. H.
Symons, W. E.

Tawse, Robert.
Terrill, C. H.
Thomas, H. T.
Thomas, J. J., Jr.
Thomas, P. G.
Thomas, W. H.
Thompson, W. O.
Thornton, C. J.
Todd, L. C.
Tollerton, W. J.
Tonge, John.
Turner, J. S.
Turner, L. H.

Van Buskirk, H. C.
Van Doren, G. L.
Vaughan, H. H.

Wagstaff, George.
Wahlen, John.
Waitt, A. M.
Wallace, W. G.
Walsh, F. O.
Walsh, J. F.
Walton, E. A.
Warren, Beriah.
Waters, J. J.
Watters, J. H.
Watts, A. H.
Webb, E. R.
Weisgerber, E. L.
Wells, M. E.
West, G. W.
Wheatley, A. W.
Whyte, F. M.
Wildin, G. W.
Wilson, W. H.
Wirt, G.
Witherspoon, D.
Woodbridge, H. C.
Wright, R. V.
Wyman, R. L.

Young, C. B.

Zang, P. C.
Zerbee, F. J.

THE PRESIDENT: The first order of business is the approval of the minutes of the 1906 convention. Inasmuch as they have been printed and distributed for some time, they will, unless there is some objection, stand approved as printed.

The next order of business is the report of the Secretary and Treasurer.

THE SECRETARY:

To the President and Executive Committee of the American Railway Master Mechanics' Association:

In accordance with the usual custom at our annual convention, I append herewith statement showing the membership of the Association and receipts and expenditures during the year just closed:

ACTIVE MEMBERSHIP.

Membership, June, 1906		781
Transferred to honorary membership	2	
Deaths	10	
Resignations	12	
Dropped, non-payment of dues and mail returned.	6	
		30
		751
New members during the year	66	
Reinstated	2	
		68
Total membership		819

ASSOCIATE MEMBERSHIP.

Membership, June, 1906	17

HONORARY MEMBERSHIP.

Membership, June, 1906	40
Transferred from active	2
	42
Deaths	2
Total membership	40

TOTAL MEMBERS.

Active	819
Associate	17
Honorary	40
Total	876

At the convention of 1906 Messrs. A. J. Cromwell and F. M. Twombly were transferred to honorary membership.

During the year the following resignations were received:

Active members: David Holtz, C. R. Yohn, G. W. Kenney, R. P. Schilling, G. H. Gilman, S. T. Balkam, K. P. Alexander, V. B. Lang, Allen Vail, Jos. Billingham, W. H. Taft and F. B. Morrison.

The following deaths have been recorded:

Active members: T. D. McDonald, J. L. Driscoll, Alberto Villasenor, Jas. Hardie, John O'Brien, Wm. Fuller, Thos. Coyle, J. H. Fildes, M. Dunn, O. H. Jackson.

Honorary members: W. H. Lewis and D. O. Shaver.

The following names have been taken from the list of members because of non-payment of dues, or on account of their mail being returned:

Active members: W. E. McEldowney, F. P. Barnes, H. E. Nichols, Isaac Rova, H. C. Smith, H. O. Gossett.

The following is a list of members added to the roll during the year:

George Akans, M. M., Southern Ry., Selma, Ala.

C. E. Allen, M. M., N. P. Ry., Glendive, Mont.

C. W. Allen, Gen. Motive Power Foreman, Phila. & Reading Ry., Reading, Pa.

J. S. Allport, Gen. Foreman, Copper Range Ry., Houghton, Mich.

A. B. Appler, M. E., Dela. & Hudson R. R., Green Island, N. Y.

W. H. Barrows, M. M., K. C. So. Ry., Shreveport, La.

N. N. Boyden, M. M., Southern Ry., Birmingham, Ala.

H. M. Carson, Asst. to Gen. Mgr., Penna. R. R., Philadelphia, Pa.

L. L. Collier, M. M., L. & N. W. Ry., Gibsland, La.

J. M. Collins, M. M., N. Y. N. H. & H. R. R., E. Hartford, Conn.

J. J. Conners, Dist. M. M., C. M. & St. P. Ry., Dubuque, Iowa.

D. W. Cunningham, M. M., C. R. I. & P. Ry., Valley Junction, Iowa.

J. F. DeVoy, M. E., C. M. & St. P. Ry., Milwaukee, Wis.

G. S. Edmonds, M. M., D. & H. Co., Oneonta, N. Y.

Emerson Harrington, Couns. Engr., A. T. & S. F. Ry., Topeka, Kan.

O. A. Fisher, M. M., A. T. & S. F. Ry., La Junta, Colo.

Henry Fowler, Asst. Wks. Mgr., Midland Ry., Derby, England.

M. D. Franey, Supt. Shops, L. S. & M. S. Ry., Collinwood, Ohio.

J. C. Fraps, M. M., Aberdeen & Asheboro Ry., Briscoe, N. C.

Thos. Fraser, M. M., Algoma Cent. Ry., Sault Ste. Marie, Ont.

J. T. Flavin, M. M., Ind., Ill. & So. Ry., Kankakee, Ill.

J. G. da Silva Friere, Loco. Supt., Cent. Ry. of Brazil, Rio de Janeiro, Brazil.

G. W. French, M. M., L. R. & H. S. W. R. R., Hot Springs, Ark.

C. E. Gossett, M. M., R. I. Lines, Elsdon, Mo.

G. M. Gray, M. E., B. & L. E. R. R., Greenville, Pa.

F. W. Gutbrod, Technical Attaché, Prussian State Ry., Berlin, Germany.

Robt. J. Hardie, Managing Director, Union Fdy. & Machine Wks., Valparaiso, Chile.

W. H. Hamilton, D. M. M., A. T. & S. F. Ry., Argentine, Kan.

H. H. Harrington, M. M., Erie R. R., Susquehanna, Pa.

P. J. Harrigan, M. M., B. & O. R. R., Connellsville, Pa.

A. C. Hinkley, M. M., C. H. & D. Ry., Lima, Ohio.

H. L. Hobbs, M. M., South & Western Ry., Johnson City, Tenn.

A. W. Horsey, M. E., Can. Pac. Ry., Montreal, Can.

G. S. Hunter, G. M. M., International & Gt. Nor. Ry., Palestine, Tex.

Harry Jackson, M. M., Interoceanic Ry., Pueblo, Mex.

Jacob Kastlin, Supt., Davenport Loco. Wks., Davenport, Iowa.

W. H. Lindsley, M. M., Florida Ry., Alton, Fla.

J. C. Little, M. E., C. & N.-W. Ry., Chicago, Ill.

A. W. Lord, S. M. P., Quincy & Torch Lake R. R., Hancock, Mich.

Thos. Marshall, M. M., C. St. P. M. & O. Ry., St. Paul, Minn.

Walter May, M. M., C. C. C. & St. L. Ry., Louisville, Ky.

F. A. McArthur, M. M., Frisco System, Springfield, Mo.

Hugh Montgomery, Gen. Foreman, C. R. R. of N. J., Jersey City, N. J.

W. F. Moran, M. M., Southern Ry., Sheffield, Ala.

G. A. Moriarty, M. M., Erie R. R., Port Jervis, N. Y.

J. F. Newhouse, M. M., Ky. & Ind. Bridge & R. R. Co., Louisville, Ky.

Louis Pfafflin, M. M., Indianapolis Union Ry., Indianapolis, Ind.

F. P. Pfahler, M. E., W. & L. E. Ry., Norwalk, Ohio.

A. J. Poole, M. M., S. A. L. Ry., Atlanta, Ga.

M. J. Powers, M. M., D. & H. Co., Carbondale, Pa.

W. B. Russell, Asst. Supt. Apprentices, N. Y. C. Lines, New York, N. Y.

T. O. Sechrist, M. M., C. N. O. & T. P. Ry., Chattanooga, Tenn.

C. W. Seddon, S. M. P. & C., D. M. & N. Ry., Proctor, Minn.

R. T. Shea, Inspr. of Tools & Mach., N. Y. C. Lines, New York, N. Y.

John Shelaberger, M. M., Southern Pacific Ry., Bakersfield, Cal.

H. C. Shields, Supt., L. & N. E. Ry., Pen Argyl, Pa.

F. A. Smock, Gen. Foreman, Penna. R. R., Jersey City, N. J.

C. M. Stuart, M. M., Phila. & Reading Ry., Tamaqua, Pa.

J. A. Turner, A. M. M., C. St. P. M. & O. Ry., Itasca, Minn.

M. H. Watkins, M. M., I. C. Railroad, Water Valley, Miss.

M. E. Wells, A. M. M., W. & L. E. Ry., Massillon, Ohio.

D. H. Wilson, Jr., Elec Engr., Erie Railroad, Meadville, Pa.

David Witherspoon, A. M. M., C. R. R. of N. J., Mauch Chunk, Pa.

H. C. Woodbridge, M. M., B. R. & P. Ry., E. Salamanca, N. Y.

R. Griffith, M. M., Colo. Midland Ry., Colorado City, Colo.

Chas. James, M. M., Erie R. R., Galion, Ohio.

REINSTATED.

A. F. Stewart, M. M., Ches. & Ohio Ry., Clifton Forge, Va.

A. B. Withers, 321 Chatham ave., Sanford, Fla.

RECEIPTS.

To dues collected from members		$3,784.00
" sale of Proceedings		1,106.55
" Ryerson scholarship fund		600.00
" sale of Index of Proceedings		1.00
" error in listing deposits	$ 1.61	
" " of bank in returning check	37.50	
		39.11
		$5,530.66

EXPENSES.

Paid exchange		$ 20.60
" expenses convention, 1906		95.00
" stamps and stamped envelopes		323.20
" office supplies and expenses		160.49
" printing		2,405.08
" expenses committees		28.65
" express		3.46
" blue-prints, tracings		96.50
" salary, Secretary		1,200.00
" reporting convention, 1906		150.90
" office rent		200.16
" surety bond, Secretary		6.80
" zinc cuts, etc.		97.77
" Ryerson scholarship		600 00
" telephone and telegraph service		65.25
" to error in listing deposits	$ 1.16	
" to error of bank in returning check	37.50	
		38.66
" balance remitted to Treasurer		38.14
Total		$5,530.66

The bills against the Association have been paid except for the preparation of one report which was printed after the books were closed.

The unpaid dues amount to $1,150.00.

A statement showing the members in arrears for dues and the amount thereof is presented herewith for the information of the members, amounting to $1,150.00.

A detailed statement of the dues collected during the year is herewith appended and made part of the report.

SCHOLARSHIPS.

The possessor of the Jos. T. Ryerson & Son scholarship at Purdue University, Mr. A. B. Marsh, finished his four years' course last week.

Messrs. Jos. T. Ryerson & Son have kindly consented to continue the scholarship another four years, and a notice to that effect was given the members.

Of the four scholarships at Stevens Institute of Technology, Hoboken, New Jersey, there are three vacancies. Mr. Arthur E. Mervine graduates this month.

Respectfully submitted,

Jos. W. Taylor,
Secretary.

DETAILED STATEMENT OF DUES COLLECTED FROM MEMBERS.

1906.		
June 13	E. A. Walton..$	5.00
" 13	R. R. Young....	5.00
" 13	P. J. Hickey....	5.00
" 14	Jno. Howard ..	5.00
" 14	W. H. Hudson.	10.00
" 14	W. P. Hobson..	5.00
" 15	Wm. Smith	5.00
" 15	S. J. Dillon....	5.00
" 15	C. M. Taylor...	5.00
" 15	W. J. Haynen..	5.00
" 15	J. Patton	5.00
" 15	W. F. Teat.....	5.00
" 15	O. Stewart	5.00
" 16	H. Tandy	5.00
" 16	D. Brown	5.00
" 16	C. W. Allen....	5.00
" 16	G. S. Allen.....	5.00
" 16	J. W. Taylor...	5.00
" 16	Frank Robinson	10.00
" 16	J. H. Walters..	5.00
" 16	G. H. Haselton.	5.00
" 16	E. Chamberlin..	5.00
" 16	J. O. Bradeen..	5.00
" 16	H. Delaney.....	5.00
" 16	J. A. Pilcher...	5.00
" 16	I. N. Kalbaugh.	5.00
" 16	John Hill	5.00
" 16	T. M. Feeley...	5.00
" 16	T. R. Browne...	10.00
" 16	J. Mackenzie ...	5.00
	Carried forward ......$	165.00

	Brought forward ......$	165.00
June 16	W. T. Fitzgerald.	5.00
" 16	H. T. Passmore	5.00
" 16	O. H. Reynolds.	5.00
" 16	E. T. James....	5.00
" 16	John Tonge ...	5.00
" 16	Geo. Wagstaff..	5.00
" 16	E. T. Sedgewick	5.00
" 16	S. W. Miller...	5.00
" 16	W. B. Leach....	5.00
" 16	H. Shoemaker..	5.00
" 17	W. H. Kinney..	5.00
" 18	W. H. Hill.....	5.00
" 18	M. J. McCarthy	5.00
" 18	R. Preston	5.00
" 18	J. B. Elliott....	5.00
" 18	G. L. Van Doren	5.00
" 18	C. Kyle	5.00
" 18	H. S. Hunter...	5.00
" 18	A. B. McHaffie.	5.00
" 18	W. H. Huffman	5.00
" 18	Jno. Wahlen ...	5.00
" 18	B. Haskell.....	5.00
" 18	C. R. Ord......	5.00
" 18	L. B. Ferguson.	5.00
" 18	Wm. McIntosh.	5.00
" 18	H. B. Brown...	5.00
" 18	R. F. Hofman..	5.00
" 18	Thos. Fildes ...	5.00
" 18	S. J. Delaney...	5.00
" 18	P. T. Lonergan.	5.00
	Carried forward ......$	315.00

Brought forward ......$		315.00
June 18	J. R. Bisset.....	5.00
" 18	B. E. Greenwood	5.00
" 18	C. H. Terrill...	5.00
" 18	G. Wirt	5.00
" 18	J. E. O'Hearne .	5.00
" 18	C. E. Chambers.	5.00
" 18	J. B. Michael...	5.00
" 18	D. A. Smith....	5.00
" 18	E. T. Sumner...	5.00
" 18	C. L. Aiken.....	10.00
" 18	John Gill	5.00
" 18	Wm. Cockfield .	5.00
" 18	J. F. Sheahan..	10.00
" 18	W. S. Murrian..	5.00
" 18	J. Hainen	5.00
" 18	D. H. Deeter...	5.00
" 18	T. D. Mannion..	5.00
" 18	A. J. Fries.....	5.00
" 18	A. M. White....	5.00
" 18	G. W. Mudd...	5.00
" 18	T. F. Barton...	5.00
" 18	W. H. Nuttall..	5.00
" 18	E. N. Weist....	5.00
" 18	J. B. Kilpatrick.	5.00
" 18	R. F. Kilpatrick.	5.00
" 18	R. D. Hawkins.	10.00
" 18	J. J. Ewing.....	5.00
" 18	J. Christopher .	5.00
" 18	V. U. Powell...	5.00
" 18	A. G. Turnbull.	5.00
" 26	W. E. Symons..	5.00
" 26	S. M. Dolan....	5.00
" 26	H. W. Burkheimer	5.00
" 26	H. G. Hudson..	5.00
" 26	Harry Ashton .	5.00
" 26	Patrick Ryan ..	5.00
" 26	J. W. Roberts..	5.00
" 26	D. J. Mullen....	5.00
" 26	John Harrison .	10.00
" 26	J. T. McGrath..	5.00
" 26	B. H. Gray.....	5.00
" 29	W. L. Harrison.	5.00
Carried forward ......$		545.00

Brought forward ......$		545.00
June 20	W. A. Brown...	5.00
" 30	C. A. Seley.....	5.00
" 30	W. S. Morris...	5.00
" 30	J. B. Barnes....	5.00
" 30	W. H. V. Rosing	5.00
" 30	H. F. Ball......	5.00
July 2	G. M. Gray.....	5.00
" 2	J. F. Newhouse.	5.00
" 2	H. C. Shields...	5.00
" 2	F. W. Gutbrod..	5.00
" 2	D. W. Cunningham	5.00
" 2	A. J. Poole.....	5.00
" 2	J. J. Conners...	5.00
" 2	M. J. Powers...	5.00
" 2	F. A. McArthur.	5.00
" 2	G. S. Edmonds.	5.00
" 2	F. A. Smock....	5.00
" 3	G. Lanza	5.00
" 3	W. O. Thompson	5.00
" 3	J. H. Maysilles.	5.00
" 3	S. F. Prince, Jr.	5.00
" 3	G. W. Wildin..	5.00
" 3	E. M. Herr.....	5.00
" 3	R. J. Gross.....	5.00
" 3	John Medway ..	5.00
" 3	L. C. Noble.....	5.00
" 3	J. F. Enright...	5.00
" 3	W. G. Menzel...	5.00
" 3	R. L. Ettenger..	5.00
" 3	Samuel Higgins.	5.00
" 3	W. C. Arp......	5.00
" 3	C. H. Howard..	5.00
" 3	W. B. Warren..	5.00
" 3	S. T. Park......	5.00
" 3	P. Maher	5.00
" 3	J. E. Keegan...	5.00
" 3	G. E. Parks....	5.00
" 3	R. M. Galbraith	5.00
" 3	Geo. S. Hodgins	5.00
" 3	W. W. Atterbury	5.00
" 3	G. R. Henderson	5.00
" 3	G. L. Dickson..	5.00
Carried forward ......$		755.00

Brought forward ......$			755.00
July	3	H. B. Ayers....	5.00
"	3	I. N. Wilbur....	5.00
"	3	Samuel Watson.	5.00
"	3	J. G. Neuffer...	5.00
"	3	Geo. James	5.00
"	3	F. F. Hildreth..	5.00
"	3	P. J. Harrigan..	5.00
"	3	A. W. Horsey..	5.00
"	3	J. F. Flavin.....	5.00
"	5	Tracy Lyon	5.00
"	5	R. O. Cumback.	5.00
"	5	W. E. Dunham.	5.00
"	5	J. W. Marden..	5.00
"	5	F. J. Smith.....	5.00
"	5	J. A. McRae....	5.00
"	5	C. A. Delaney..	5.00
"	5	J. D. Harris....	5.00
"	9	C. M. Mendenhall	5.00
"	9	H. Monkhouse .	5.00
"	9	C. H. Davis....	5.00
"	9	D. J. Justice....	5.00
"	9	Thos. Paxton ..	5.00
"	9	Wm. Garstang .	5.00
"	9	J. J. Monahan..	5.00
"	9	J. F. Walsh....	5.00
"	9	F. Hedley	5.00
"	9	Wm. Buchanan.	5.00
"	9	Thos. Millen ...	5.00
"	9	A. J. Dunn.....	5.00
"	9	E. D. Nelson...	5.00
"	9	A. S. Vogt.....	5.00
"	9	A. W. Gibbs....	5.00
"	9	W. F. M. Goss.	5.00
"	9	J. H. Manning..	5.00
"	9	W. H. Taylor..	5.00
"	9	J. H. Clark.....	5.00
"	9	G. K. Hatz.....	5.00
"	9	Henry Bartlett .	5.00
"	9	W. T. Thompson	5.00
"	9	H. Emerson ...	5.00
"	9	L. D. Gillett....	5.00
"	9	H. T. Peyton...	10.00
Carried forward ......$			970.00

Brought forward ......$			970.00
July	9	H. H. Vaughan.	5.00
"	9	R. M. McDougall	5.00
"	9	F. C. Cleaver...	5.00
"	9	T. W. Heintzelman	5.00
"	9	C. F. Street....	5.00
"	9	F. W. Brazier..	5.00
"	9	W. E. Chester..	5.00
"	9	C. B. Royal....	5.00
"	9	A. H. Watts....	5.00
"	9	F. P. Roesch...	5.00
"	9	J. R. Magarvey.	5.00
"	9	L. H. Turner...	5.00
"	9	M. J. Rogers...	5.00
"	9	Willard Kells ..	5.00
"	9	J. P. McCuen...	5.00
"	9	A. M. Waitt....	5.00
"	9	F. R. Cooper...	5.00
"	9	Geo. Gibbs	5.00
"	9	Wm. Miller	5.00
"	9	A. J. Cota......	5.00
"	9	M. H. Wickhorst	5.00
"	9	F. A. Casey....	5.00
"	9	A. E. Mitchell..	5.00
"	9	C. H. Quereau..	5.00
"	9	J. E. Sague.....	5.00
"	9	W. H. Thomas.	5.00
"	9	C. E. Rettew...	5.00
"	9	G. W. West....	5.00
"	9	W. J. Miller....	10.00
"	14	H. T. Thomas..	5.00
"	14	W. H. Richmond	5.00
"	14	Wm. Renshaw .	5.00
"	14	J. F. Deems....	5.00
"	14	W. A. Smith...	5.00
"	14	F. J. Cole......	5.00
"	14	E. T. White....	5.00
"	14	R. E. Smith....	5.00
"	14	T. A. Foque....	5.00
"	14	M. Dunn	5.00
"	14	W. J. McLean..	5.00
"	14	W. L. Austin...	5.00
Carried forward ......$			1,180.00

Brought forward		......	$1,180.00
July	14	S. M. Vauclain..	5.00
"	14	A. B. Johnson..	5.00
"	14	Beriah Warren .	5.00
"	14	S. P. Bush.....	5.00
"	14	F. H. Clark....	5.00
"	14	F. A. Chase....	5.00
"	14	A. Stewart	5.00
"	14	B. B. Cargo....	5.00
"	14	C. G. Turner...	5.00
"	14	P. H. Murphy..	5.00
"	14	R. D. Smith....	5.00
"	14	J. A. Hill......	5.00
"	14	L. S. Randolph.	5.00
"	14	Geo. Gilmour ..	5.00
"	14	A. G. Leonard..	5.00
"	14	W. H. Marshall	5.00
"	14	Amos Turner ..	5.00
"	14	Thos. Coyle	5.00
"	14	Jas. Buchanan .	5.00
"	14	T. E. Keyworth.	5.00
"	14	D. F. Crawford.	5.00
"	14	F. M. Whyte...	5.00
"	14	David Clark ...	5.00
"	14	Wm. Jennings .	5.00
"	14	V. B. Lang.....	5.00
"	14	A. Forsyth.....	5.00
"	14	J. L. Greatsinger	5.00
"	14	J. A. Carney....	5.00
"	14	D. A. Wightman	5.00
"	14	S. L. Kneass....	5.00
"	14	E. B. Gilbert...	5.00
"	14	W. H. Traver..	5.00
"	14	N. W. Sample..	5.00
"	14	H. H. Harrington	5.00
"	14	Robt. Moran ...	5.00
"	14	G. S. McKee....	5.00
"	14	W. C. Burel....	5.00
"	14	Wm. O'Herin ..	5.00
"	14	F. M. Gilbert...	5.00
"	14	W. G. Wallace.	5.00
"	14	F. A. Torrey...	5.00
"	14	T. H. Curtis....	5.00
Carried forward		......	$1,390.00

Brought forward		......	$1,390.00
July	14	W. Cross	5.00
"	14	C. S. Hall......	5.00
"	14	Robt. Quayle . .	5.00
"	14	E. A. Williams.	5.00
"	14	F. D. Casanave.	5.00
"	16	W. J. Shreve...	5.00
"	16	F. E. Davisson.	5.00
"	16	J. P. Dolan.....	5.00
"	16	C. J. Stewart...	5.00
"	16	T. A. Brown...	5.00
"	16	W. L. Gilmore..	5.00
"	16	J. A. Egan.....	5.00
"	16	T. W. Macfarlane	5.00
"	16	H. C. Woodbridge	5.00
"	21	J. P. Nolan.....	5.00
"	21	M. S. Curley...	5.00
"	21	John Hair	5.00
"	21	A. E. Manchester	5.00
"	21	A. L. Humphrey	5.00
"	21	J. J. Waters....	5.00
"	21	E. D. Bronner..	5.00
"	21	W. F. Kapp....	5.00
"	21	W. J. Bennett..	10.00
"	21	H. T. Herr.....	5.00
"	21	J. McNaughton.	5.00
"	21	J. K. Brassil....	5.00
"	21	J. A. Graham...	5.00
"	21	G. H. Emerson..	5.00
"	21	L. B. Rhodes...	5.00
"	21	Wm. Fuller	5.00
"	21	W. A. Nettleton	5.00
"	21	G. R. Bennett...	5.00
"	21	S. K. Dickerson	5.00
"	21	W. H. Stocks..	5.00
"	21	W. L. Boler....	5.00
"	21	C. Phillips	5.00
"	21	Allen Vail	5.00
"	21	R. B. Kendig...	5.00
"	21	J. J. Ryan......	5.00
"	21	A. B. Minton...	5.00
"	21	R. A. Billingham	5.00
Carried forward		......	$1,600.00

	Brought forward		$1,600.00
July	21	F. W. Lane....	5.00
"	21	H. A. Gillis....	5.00
"	21	F. O. Walsh....	5.00
"	21	J. T. Hayes....	5.00
"	21	F. T. Hyndman	5.00
"	21	C. M. Stansbury	5.00
"	21	H. N. Breneman	5.00
"	21	LeGrande Parish	5.00
"	21	G. R. Joughins.	5.00
"	21	Wilson Worsdell	5.00
"	21	Marcel Japiot ..	5.00
"	21	J. W. Cloud....	5.00
"	21	G. J. Churchward	5.00
"	21	Geo. Whale	5.00
"	31	A. F. Stewart..	15.00
"	31	W. H. Barrows.	5.00
Aug.	2	P. H. Peck.....	5.00
"	2	T. A. Lawes....	5.00
"	2	W. D. Holland.	5.00
"	2	F. A. Delano...	5.00
"	2	D. O'Leary	5.00
"	2	D. W. Ford....	5.00
"	2	J. H. Murphy..	5.00
"	2	J. N. Mowery..	5.00
"	2	Oscar Antz	5.00
"	2	C. M. Babcock..	5.00
"	2	O. H. Greard...	5.00
"	2	J. E. Cameron..	5.00
"	2	F. H. Scheffer..	5.00
"	2	H. J. Small....	5.00
"	2	T. H. Symington	5.00
"	2	J. F. Dunn.....	5.00
"	2	C. R. Williams.	5.00
"	2	J. E. Goodman..	5.00
"	2	J. W. Records..	5.00
"	2	Max Goodrich..	5.00
"	2	R. E. McCuen..	5.00
"	2	C. M. Hoffman..	5.00
"	2	P. G. Thomas..	5.00
"	2	M. G. Bock.....	5.00
"	2	T. E. Adams...	5.00
"	2	G. A. Ferguson.	5.00
	Carried forward		$1,820.00

	Brought forward		$1,820.00
Aug.	2	Arthur Dinan ..	5.00
"	2	F. T. Slayton...	5.00
"	2	P. M. Hammett.	5.00
"	2	J. R. Groves....	5.00
"	2	W. R. McKeen.	5.00
"	2	M. R. Coutant..	5.00
"	2	T. W. Demarest	5.00
"	2	A. Bardsley	5.00
"	2	J. W. Addis....	5.00
"	2	G. D. Brooke...	5.00
"	2	W. L. Kellogg..	5.00
"	2	J. R. Gould....	5.00
"	2	H. L. Leach....	5.00
"	2	E. C. Bates.....	5.00
"	2	J. E. Muhlfeld..	5.00
"	2	H. C. Van Buskirk	5.00
"	2	E. A. Miller....	5.00
"	2	P. D. Plank....	5.00
"	2	J. E. Chisholm..	5.00
"	2	H. P. Durham..	5.00
"	2	D. G. Desmond.	5.00
"	2	Jno. C. Glass...	5.00
"	2	S. R. Tuggle....	15.00
"	3	E. W. Burgis...	5.00
"	3	F. Mertsheimer.	5.00
"	3	John McGie	5.00
"	3	Jessie Gauthier .	5.00
"	3	T. S. Lloyd....	5.00
"	3	R. E. French...	5.00
"	3	I. W. Fowle....	5.00
"	7	T. S. Beauclerk.	5.00
"	7	Henry Pearse ..	5.00
"	7	G. M. Basford..	5.00
"	7	J. E. Gould.....	5.00
"	7	W. H. Lewis...	5.00
"	7	A. Kearney	5.00
"	7	Angus Sinclair .	5.00
"	7	E. Ryan	5.00
"	7	J. F. Fleischer..	5.00
"	7	R. A. Smart....	5.00
"	7	F. M. McNulty.	5.00
"	7	W. S. Hancock.	5.00
	Carried forward		$2,040.00

Brought forward			$2,040.00
Aug.	7	E. B. Thompson	5.00
"	7	J. W. Fogg.....	5.00
"	7	W. C. Walsh...	5.00
"	14	J. J. Ellis.......	5.00
"	14	J. J. Casey......	5.00
"	14	H. B. Hunt.....	5.00
"	14	H. H. Kendall..	5.00
"	14	L. L. Bentley...	5.00
"	14	A. B. Appler....	5.00
"	14	F. M. Pierce....	5.00
"	14	D. Van Alstyne	5.00
"	15	H. S. Hayward.	5.00
"	15	Geo. Collier	5.00
"	15	Georges Asselin.	5.00
"	15	E. J. Smith.....	5.00
"	15	F. G. Ferguson.	5.00
"	15	C. H. Welch....	5.00
"	15	Wm. Schlafge..	5.00
"	15	D. E. Cassidy...	5.00
"	15	C. E. Gossett...	5.00
"	21	Henry Elliott...	5.00
"	21	D. H. Wilson, Jr.	5.00
"	21	Owen Clarke ...	5.00
"	21	J. J. Connolly...	5.00
"	21	R. Tawse	10.00
"	21	J. S. Chambers.	5.00
"	21	R. N. Durborow	5.00
"	21	J. S. Cook......	5.00
"	21	F. B. Barclay...	5.00
"	21	Frank Singer ..	15.00
"	21	A. Shields	5.00
"	21	G. T. Neubert..	5.00
"	21	F. Hufsmith ...	5.00
"	21	J. E. Irvin......	5.00
Sept.	5	G. L. Fowler...	5.00
"	5	H. M. Pflager..	5.00
"	5	John Hopwood .	5.00
"	5	J. R. Van Cleve.	5.00
"	5	C. W. Cross....	5.00
"	5	C. H. Barnes...	5.00
"	5	C. H. Hogan...	5.00
"	5	T. J. Cutler....	5.00
"	5	H. T. Bentley..	5.00
Carried forward			$2,270.00

Brought forward			$2,270.00
Sept.	5	G. H. Bussing..	5.00
"	5	W. E. Amann....	5.00
"	5	W. F. Post.....	5.00
"	5	L. S. Kinnaird..	5.00
"	5	W. J. Thomas..	10.00
"	5	E. S. Hume.....	5.00
"	12	Thos. Marshall .	5.00
"	12	J. A. Turner....	5.00
"	14	W. J. Schlacks..	10.00
"	14	L. A. Shepard..	5.00
"	14	Ben Johnson ...	5.00
"	14	C. R. Hillman...	5.00
"	14	J. B. Morgan...	5.00
"	14	W. C. Squire...	5.00
"	14	W. M. Taylor..	5.00
"	14	W. F. Bradley..	5.00
"	17	L. C. Todd.....	10.00
"	17	W. Sinnott	5.00
"	17	D. J. Redding..	5.00
"	17	A. L. Studer...	5.00
"	21	J. W. Harkom..	5.00
"	21	Louis Greaven .	5.00
"	21	F. H. Neward..	5.00
"	21	A. L. Beattie....	10.00
"	21	W. N. Best.....	5.00
"	21	C. L. Meister...	5.00
"	26	Robt. Gould ...	5.00
"	26	W. L. Reid....	5.00
"	26	S. J. Hungerford	5.00
"	26	W. H. Lindsley.	5.00
"	28	Maynard Robinson	5.00
Oct.	15	Jas. Macbeth ..	5.00
"	15	W. C. Ennis....	5.00
"	15	W. Augustus ..	5.00
"	15	W. J. Tollerton.	5.00
"	15	Jos. Chidley ...	5.00
"	15	H. L. Aldana...	5.00
"	15	Bert Hartigan ..	5.00
"	15	W. H. Brehm..	5.00
"	15	J. E. Muhlfeld..	5.00
"	15	J. Horrigan	5.00
Carried forward			$2,495.00

Brought forward			$2,495.00
Oct.	15	C. F. Chase....	5.00
"	15	R. M. Boldridge	5.00
"	15	A. B. Adams...	5.00
"	15	F. G. Benjamin.	5.00
"	15	A. C. Hinckley.	5.00
"	18	Geo. Gurry	5.00
"	18	W. L. Tracy...	5.00
"	18	C. H. Wiggin..	5.00
"	22	C. J. Thornton.	5.00
"	22	R. T. Shea.....	5.00
"	22	Theo. Laurent .	5.00
"	22	W. E. Knight..	5.00
"	22	D. R. MacBain.	5.00
Nov.	5	C. M. Muchnic.	5.00
"	5	H. B. Howe....	5.00
"	5	C. E. Fuller....	5.00
"	5	J. G. De Silva..	5.00
"	5	L. R. Johnson..	5.00
"	13	P. H. Minshull.	5.00
"	13	M. D. Franey...	5.00
"	15	A. B. Withers..	10.00
"	27	G. S. Hunter...	5.00
"	27	C. H. Seabrook.	5.00
"	27	J. A. Gibson....	5.00
Dec.	6	G. W. French..	5.00
"	7	A. R. Kipp.....	5.00
"	7	G. A. Hancock.	5.00
"	10	C. H. Prescott..	10.00
"	17	F. F. Gaines....	5.00
"	17	E. E. Davis.....	5.00
"	26	F. H. Litton....	5.00
"	31	C. E. Allen.....	5.00
"	31	Jas. Fitzmorris.	5.00
"	31	J. S. Turner....	5.00
"	31	C. A. Bingaman.	5.00
"	31	J. W. Taylor...	10.00
1907.			
Jan.	4	A. G. Machesney	5.00
"	11	A. F. Stewart...	5.00
"	11	Louis Pfafflin ..	5.00
"	11	T. Sakuma	5.00
"	19	W. D. Robb....	5.00
"	19	L. M. Kidd.....	5.00
Carried forward			$2,720.00

Brought forward			$2,720.00
Jan.	23	Wm. Forsyth ..	5.00
"	23	Chas. DeGress .	5.00
Feb.	4	H. Swoyer	15.00
"	4	C. W. Stevenson	5.00
"	4	R. V. Wright...	5.00
"	4	A. Lovell	5.00
"	7	M. K. Barnum..	5.00
"	7	R. H. Johnson..	10.00
"	7	A. C. Deverell..	5.00
"	7	W. H. Hamilton	5.00
"	11	L. R. Pomeroy.	5.00
"	11	J. J. Sullivan...	5.00
"	19	C. H. Temple..	5.00
"	19	J. W. Hill......	5.00
"	19	H. M. C. Skinner	5.00
"	19	E. W. Pratt....	5.00
"	19	C. B. Smith....	5.00
"	19	Wm. Hassman..	5.00
"	19	C. W. Allen....	5.00
"	19	C. J. McMasters	5.00
"	19	H. G. Bechhold	5.00
"	19	J. S. Pearce....	5.00
"	19	John Dickson .	5.00
"	19	J. S. Patterson .	5.00
"	19	Thos. Jennings .	5.00
"	19	F. B. Smith....	5.00
"	19	R. J. Goodale...	5.00
"	19	H. D. Gordon...	5.00
"	19	C. J. Mellin	5.00
"	19	C. A. Thompson	5.00
"	19	L. L. Dawson...	10.00
"	19	H. Tregelles ...	5.00
"	19	T. B. Purves, Jr.	5.00
"	19	Joseph Roberts .	5.00
"	19	M. J. Drury....	4.00
"	22	F. J. Zerbee....	5.00
"	22	J. H. McGoff...	5.00
"	22	W. M. Paul....	5.00
"	22	W. B. Gaskins..	5.00
"	22	Geo. Thompson.	10.00
"	22	Thos. Rumney .	5.00
"	22	B. H. Hawkins.	5.00
Carried forward			$2,954.00

Brought forward			$2,954.00
Feb.	22	R. H. Soule	5.00
"	22	M. D. Stewart	5.00
"	22	R. H. Briggs	5.00
"	22	H. Green	5.00
"	26	David Witherspoon	5.00
"	26	H. L. Hobbs	5.00
"	27	H. A. Lyddon	10.00
"	27	G. E. Branch	5.00
"	27	Wm. Lachlan	10.00
"	27	I. W. Clark	5.00
"	27	W. H. Russell	5.00
"	27	A. B. Todd	5.00
"	27	Thos. Booth	5.00
"	27	H. S. Bryan	5.00
"	27	J. H. McConnell	5.00
"	27	J. W. Balderston	5.00
Mar.	4	J. S. Allport	5.00
"	4	W. F. Yergens	5.00
"	4	Thos. Roope	5.00
"	4	H. Stillman	10.00
"	4	Wilbur Green	5.00
"	4	H. Wade Hibbard	5.00
"	4	M. E. Wells	5.00
"	4	T. M. Gibb	5.00
"	4	W. S. Gallaway	5.00
"	4	Phillip Wallis	5.00
"	4	B. P. Flory	5.00
"	8	Thos. Aldcorn	5.00
"	8	T. A. Summerskill	5.00
"	8	J. S. Booth	5.00
"	8	P. H. Brangs	5.00
"	8	A. McCormick	5.00
"	8	Jas. Hardie	5.00
"	8	E. F. Needham	5.00
"	11	W. G. Edmonson	10.00
"	11	J. Potton	5.00
"	11	J. McManamy	5.00
"	16	Robt. Patterson	5.00
"	16	W. T. Clarkson	5.00
Carried forward			$3,169.00

Brought forward			$3,169.00
Mar.	16	C. D. Hilferty	5.00
"	16	W. H. Collins	5.00
"	16	Geo. Dickson	5.00
"	23	J. H. Rice	5.00
"	23	J. A. Turtle	5.00
"	23	P. C. Rusch	5.00
"	23	C. E. Uddenberg	5.00
"	23	R. A. Johnson	5.00
"	23	M. S. Monroe	5.00
"	23	C. B. Young	5.00
"	23	R. J. Hardie	5.00
Apr.	2	G. B. Nutt	5.00
"	2	V. Z. Caracristi	5.00
"	2	J. B. Miller	5.00
"	2	E. Dawson	5.00
"	2	D. M. Pearsall	10.00
"	2	T. McNabb	5.00
"	2	D. Van Ripper	5.00
"	2	H. C. Manchester	5.00
"	8	P. D. Plank	5.00
"	8	I. C. Hicks	5.00
"	8	T. M. Markle	5.00
"	11	M. J. Rogers	5.00
"	19	Rufus Hill	5.00
"	19	G. W. Butcher	5.00
"	19	F. J. Leigh	5.00
"	19	J. G. Clifford	5.00
"	19	A. C. Adams	5.00
"	19	J. M. Robb	5.00
"	20	E. G. Bryant	5.00
"	20	P. H. Reeves	5.00
"	27	W. H. Murray	10.00
"	27	H. E. Walker	10.00
"	27	T. McHattie	5.00
"	27	J. I. Krauss	5.00
"	27	Max Toltz	5.00
"	30	Richard English	10.00
"	30	J. Piccioli	5.00
"	30	Harry Jackson	5.00
May	2	L. L. Collier	5.00
"	13	G. W. Seidel	5.00
"	13	Wm. Alport	10.00
Carried forward			$3,404.00

Brought forward			$3,404.00
May	13	Wm. White	5.00
"	13	G. A. Gallagher.	5.00
"	13	Jos. Billingham.	10.00
"	13	W. T. Smith	5.00
"	13	W. H. Prendergast	5.00
"	13	Wm. Montgomery	5.00
"	13	J. B. Gannon	10.00
"	13	T. J. Cole	5.00
"	13	J. J. Ewing	5.00
"	13	F. E. Place	10.00
"	13	D. G. Desmond.	5.00
"	13	A. H. Gairns	5.00
"	13	F. Tuma	5.00
"	13	J. L. Smith	5.00
"	13	Edw. Elden	5.00
"	13	A. G. Turnbull.	5.00
"	13	S. N. Woodruff.	5.00
"	13	G. A. Bruce	5.00
"	13	Wm. Miller	5.00
"	13	Wm. Moir	5.00
"	13	Thos. Walsh	10.00
"	13	J. M. Dow	5.00
"	13	Patrick Ryan	5.00
"	13	Samuel Shepard	5.00
"	13	C. T. Noyes	5.00
"	13	A. L. Moler	10.00
"	13	J. C. Nolan	5.00
"	13	W. F. Doonan	10.00
"	13	G. F. Wilson	5.00
"	15	F. P. Phahler	5.00
Carried forward			$3,584.00

Brought forward			$3,584.00
May	15	W. T. Foster	5.00
"	15	C. W. Lee	5.00
"	15	O. C. Cromwell.	5.00
"	15	Jas. Ashworth	5.00
"	17	T. F. Brady	5.00
"	17	T. C. Link	5.00
"	17	J. P. Dolan	5.00
"	17	E. L. Weisgerber	15.00
"	23	H. G. Hudson	5.00
"	23	Grant Hall	5.00
"	23	Jas. Kirkpatrick	15.00
"	23	J. H. Tinker	5.00
"	23	W. H. Owens	5.00
"	23	M. B. Parker	5.00
"	23	J. G. Platt	5.00
"	23	W. H. Wilson	5.00
"	23	C. T. McElvaney	5.00
"	23	Geo. Akans	5.00
"	23	N. N. Boyden	5.00
"	23	W. F. Moran	5.00
"	23	C. D. Vanaman.	5.00
"	23	G. A. Miller	5.00
"	27	J. Christopher	5.00
"	27	F. M. Fryburg.	5.00
"	27	A. S. Grant	15.00
"	27	W. S. Grandy	5.00
"	27	D. Holtz	5.00
"	31	J. G. Beaumont	10.00
"	31	R. F. Hoffman.	5.00
"	31	D. J. Mullen	5.00
"	31	Jas. McDonough	5.00
"	31	Jno. Hawthorne	5.00
"	31	J. W. Roberts	5.00
			$3,784.00

On motion the report of the Secretary was received.

TREASURER'S REPORT.

To the President and Executive Committee:

Balance on hand June, 1906	$1,870.79
Coupons on mortgage bond, Jerome Wheelock	40.00
Interest on deposits to June, 1907	28.32
	$1,939.11
Less paid to H. Vaughan	200.00
	$1,739.11

Also on hand bond of the Mortgage Bond Company No. 212, at four per cent, for $1,000.

ANGUS SINCLAIR,
Treasurer.

NEW YORK, June 11, 1907.

Mem.: $38.14 turned over to Treasurer by Secretary since foregoing statement was made.

MR. PECK: I move that the reports of the Secretary and Treasurer be received and referred to the Auditing Committee. (Carried.)

THE SECRETARY: The Executive Committee at its meeting last evening agreed to recommend that the dues for the current year be fixed at $5, the same as heretofore.

MR. F. H. CLARK: I move that the recommendation of the Executive Committee be confirmed. (Carried.)

THE PRESIDENT: The next business in order will be the election of three members of the Auditing Committee by the Association, selected from the floor, members to be selected from those other than members of the Executive Committee.

The following nominations were made: Mr. O. H. Reynolds, Mr. Robert Preston, Mr. L. R. Pomeroy.

THE PRESIDENT: The Secretary will cast the ballot of the Association for the three gentlemen nominated unless there is objection.

The Secretary duly cast the ballot and the Auditing Committee was declared elected.

THE SECRETARY: I would say to the members of the Auditing Committee that when they are ready for the books of the Secretary and Treasurer, they will find them here at the desk.

THE PRESIDENT: The next business is Unfinished Business.

THE SECRETARY: There is nothing in the shape of unfinished business.

THE PRESIDENT: New Business is in order.

MR. M. K. BARNUM: I make a motion that the American Railway Master Mechanics' Association instruct its Secretary to send a vote of thanks to the officials of the Pennsylvania lines for the very handsome special train which they furnished for the members of the Association and their friends from Chicago to Atlantic City; for the fine run and excellent service rendered; and also for the special tracks installed for use in connection with this meeting, and for other favors received.

MR. ANGUS SINCLAIR: I think that should go over until the report of the Committee on Resolutions is presented.

THE PRESIDENT: This is a special matter, not included in the routine of the Committee on Resolutions.

The President put the question on the resolution, which was carried by a rising vote.

THE SECRETARY: Mr. President, at the last convention the name of Mr. J. Snowden Bell was proposed for associate membership by Messrs. James McNaughton and J. F. Walsh. It having lain over a year as required by the Constitution, is now before the convention for action.

MR. P. H. PECK: I move that Mr. Bell be elected an Associate member. (Carried.)

THE SECRETARY: The Executive Committee submits to the convention with its approval the name of Mr. W. C. Ennis, a member of the Association since 1881, for honorary membership. Mr. Ennis has given up active railroad work. He has been a member of the Association for twenty-six years.

MR. A. M. WAITT: I move that the recommendation of the Executive Committee be adopted. (Carried.)

THE SECRETARY: The Executive Committee submits to the convention with its approval the name of Mr. Henry Elliott for

honorary membership. Mr. Elliott has been a member since 1869, the year after the organization of this Association.

MR. WILLIAM GARSTANG: I move that the recommendation of the Executive Committee be adopted, and that Mr. Elliott be elected to honorary membership. (Carried.)

THE SECRETARY: The following proposition for associate membership has been received:

We hereby propose for associate membership the name of Mr. Lawford H. Fry, Engineer of Tests, Baldwin Locomotive Works. Signed, H. F. Ball, A. E. Mitchell.

THE PRESIDENT: The application of Mr. Fry has now been before the association for two years, which is beyond the required time, and it is now for the Association to decide whether or not it wishes to admit Mr. Fry to associate membership.

MR. C. A. SELEY: I move that the proposal of Mr. Fry be accepted, and that he be elected to associate membership. (Carried.)

THE SECRETARY: The President has appointed the following committees:

On Correspondence and Resolutions: G. M. Basford, F. M. Whyte, L. R. Pomeroy.

On Obituaries: On T. D. Macdonald, Mr. J. E. Chisholm; on J. L. Driscoll, Mr. J. P. McCuen; on A. Villasenor, Mr. E. V. Sedgwick; on James Hardy, Mr. H. Tregelles; on John O'Brien, Mr. J. F. Walsh; on William Fuller, John McKenzie; on Thomas Coyle, Mr. G. W. Wildin; on J. H. Fildes, Mr. H. D. Taylor; on M. Dunn, Mr. T. W. Demarest; on O. H. Jackson, Mr. William Garstang; on W. H. Lewis, Mr. David Brown; on D. O. Shaver, Mr. D. F. Crawford; on A. J. Cromwell, Mr. E. L. Weisgerber.

THE SECRETARY: A year ago the Association received a communication from the Pennsylvania Railroad Company in regard to the work done on the locomotive testing plant at the Louisiana Purchase Exposition at St. Louis, and the Executive Committee instructed that a letter of thanks be sent to the Pennsylvania Railroad Company. The letter was prepared by a sub-

committee of the Executive Committee, and was forwarded as follows:

Mr. A. J. Cassatt, President, Penna. R. R. Co., Philadelphia, Pa.:

DEAR SIR.—Your letter of March 19 in reference to the assistance rendered by the representatives of this Association in the locomotive tests made at the Louisiana Purchase Exposition in 1904, was brought before the Executive Committee at a recent meeting and the following resolution adopted:

"That the Executive Committee of the American Railway Master Mechanics' Association express the appreciation of its membership for the information developed through the locomotive tests so generously conceived and carried out by the Pennsylvania Railroad System during the Louisiana Purchase Exposition, and testify to the proficiency and ability displayed by its organization in planning and executing the tests. That it also expresses the thanks of the Association for the opportunity of participating in these tests through its representatives on the Advisory Committee."

(Signed) JOS. W. TAYLOR, *Secretary.*

THE SECRETARY: I would repeat, as I stated in my report, that there are three vacant Master Mechanic scholarships at Stevens' Institute of Technology, Hoboken, N. J., after the commencement this week.

THE SECRETARY: The following communication has been received from Prof. W. F. M. Goss, of Purdue University:

I beg to formally report that the Ryerson Scholarship in Purdue University, which has for four years been held by Mr. A. B. Marsh, will be vacated June 12, 1907.

Believing that it will be a matter of satisfaction to you and the members of the Association, I would add that throughout his career Mr. Marsh has maintained high scholarship and has otherwise conducted himself in a manner worthy of the confidence bestowed upon him by the Master Mechanics' Association.

THE SECRETARY: Those are all the communications that I have under the head of new business.

THE PRESIDENT: I will make a suggestion before we go into the regular business, and that is with reference to the exhibits. I do not think there has ever been a time when we have had as fine a display of exhibits as we have at this convention. The supplymen have gone to a great deal of trouble, as well as the people of Atlantic City, to make an attractive exhibit, and I was won-

dering if we could not, perhaps, without any formal action, agree amongst ourselves that we would devote a certain hour of the day in looking at these exhibits. It is a great education to inspect them carefully. I was here all day yesterday and a part of the day before, and have had a chance to go over them pretty thoroughly. It is well worth the time that any one can devote to them, and I hope that no member will neglect a close inspection, but will consider it is his duty to go over them very carefully and thoroughly.

THE PRESIDENT: The next business is the report of the Committee on Mechanical Stokers, of which Mr. William Garstang is chairman.

Mr. Garstang presented the report as follows:

REPORT OF COMMITTEE ON MECHANICAL STOKERS.

To the Members:

The Standing Committee on Mechanical Stokers appointed at the convention in 1905 to observe and report on the advancement of mechanical stokers for locomotives, would report as follows:

Since the last convention, trials of the Day-Kincaid, Hayden and Krouse automatic stokers for locomotives have been continued by various railroad companies. The data obtained from these tests are not, as yet, in sufficiently conclusive shape to make it desirable to present same to the Association.

Your committee has advice that one of the larger railroads in the country has prepared designs of two types of experimental stokers, the test of which, it is expected, will be started at an early date.

The state of the art is such that your committee can only make a progress report at this time.

WM. GARSTANG (Chairman),
D. F. CRAWFORD,
J. F. WALSH,
G. S. HODGINS,
Committee.

INDIANAPOLIS, IND., May 20, 1907.

MR. ANGUS SINCLAIR: I move that the report be received and the committee continued.

THE PRESIDENT: I think this is a report upon which there should be some discussion before we dispose of it. I think every

one feels a keen interest in the question. I would like to know if Mr. Barnum can not say something on this subject. I know that on the C. B. & Q. R. R. they have been experimenting quite a good deal with a stoker.

MR. M. K. BARNUM (C. B. & Q. R. R.): I am not very familiar with those experiments, for while the stoker was tested at West Burlington, I had not the honor of inventing it.

THE PRESIDENT: We know it was another Barnum who invented it, but we thought you would be able to give us some information about it.

MR. BARNUM: The tests showed that it had considerable merit, but was not perfected so that it could be put into road service and meet all requirements; consequently the tests were discontinued pending further improvements by the inventor.

MR. WM. GARSTANG (C. C. C. & St. L. Ry.): If Mr. Hodgins, one of the members of the committee, is in the room, I believe he can give us some interesting information on this subject. If Mr. Hodgins is not present Mr. Walsh has probably had as much experience with the stoker as any Superintendent of Motive Power, and we would be glad to hear from him.

MR. J. F. WALSH (C. & O. Ry.): I do not know that I can add anything to what the chairman of the committee has just read. We had a great deal of experience with the original Kincaid stoker, and outside of some of the weaknesses of its mechanical parts we had no trouble with it. It performed the service for which it was intended on the class of engines for which it was designed, thoroughly; that was the narrow and long firebox heavy locomotives, in freight service, particularly. We have but a few of that type of locomotives compared with the wide fire-box locomotives. The result is that our narrow and long fire-box heavy consolidation engines have been to a very great extent assigned to coal districts and to short runs. The wide fire-box heavy consolidation engine has taken the place of the engine with the long, narrow fire box on the long freight runs, and with the advent of this class of engine we do not see the necessity for a mechanical stoker we thought was necessary with the other type of engine, and, as far as we are concerned, we do

not see the necessity for a locomotive stoker on the wide fire-box engine. We have no trouble going over a 125-mile division with a 4,000-ton freight train, with the widé fire-box engine, and one man firing, while with the long narrow fire-box engine of the same size it was, in warm weather particularly, a practical impossibility to get continuous, steady travel, so that I am safe in saying that so far as we are concerned the wide fire-box engine has done away with the necessity for the mechanical stoker.

THE PRESIDENT: The statements which Mr. Walsh has made are certainly very interesting. Mr. Hodgins is now present, and it has been suggested that he can probably say something on the question of the mechanical stoker.

MR. G. S. HODGINS (Railway and Locomotive Engineering): I have had an opportunity of seeing the stoker in operation on the Erie Railroad, on the Susquehanna Division. I examined it and saw how it worked. The stoker appears to operate all right, but the engine it was on was not in very good condition at the time. In a certain sense, that was satisfactory to the stoker people, as they claimed it was able to do its work against very serious leaks. We have not yet had any data from the Erie people as to the performance of the stoker. They are making a test and intend to give us some information later on.

THE PRESIDENT: Is there any further discussion on the subject? If not, the motion is that the report be received and the committee continued. (The motion was put to vote and carried.)

THE SECRETARY: Before we take up the next report I will say that Mr. W. G. Wallace appears at this convention in a dual capacity: as a member of this Association, and as past president of the Traveling Engineers' Association, and is here to represent that Association on the floor. I would move that the privileges of the floor be extended to Mr. Wallace as the representative of the Traveling Engineers' Association. (The motion was carried.)

MR. W. G. WALLACE (Detroit, Toledo & Ironton R. R.): Mr. President, on behalf of the Traveling Engineers' Association, I wish to thank the Master Mechanics' Association for their

past courtesies. As a young organization, we look, of course, to our superiors, or those older in the service, for direction. The Traveling Engineers' Association highly appreciates the courtesies extended by this Association to them in that line.

THE PRESIDENT: The next is the report of the Committee on Shrinkage Allowance for Tires, Mr. E. J. Cole, chairman.

The report was presented by Mr. Cole, as follows:

REPORT OF COMMITTEE ON TIRE SHRINKAGE AND DESIGN OF WHEEL CENTERS.

To the Members:

Your committee made a report of Shrinkage Allowance for Tires in 1905 to this Association. The suggestions of the committee at that time were as follows:

Shrinkage 1-80th of an inch per foot in diameter for cast-iron and cast-steel centers less than 66 inches in diameter.

Shrinkage 1-60th of an inch per foot in diameter for centers 66 inches and over in diameter.

Minimum thickness of tires should be established, due consideration being given to the diameter, service and weight per wheel.

Tire and wheel gauges should be of good design, heavy enough to resist bending and subject to frequent inspection to insure accuracy.

Seventy-two inches diameter of wheel center should be included in standard sizes.

Wheel center rims should preferably be uncut, but, if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal to be used.

In the discussion which followed the reading of the paper the design of the cast-steel wheel centers was considered and a motion was made by Mr. Deems to refer the subject back to the same committee, and ask them to take into account the design of wheel centers and to consider principally the question of parted or solid rim, and whether retaining rings or shoulders on the tires should be used.

At the meeting in 1906 your committee submitted a report as requested, but unfortunately none of the members were present at the meeting (the chairman being absent on a Western trip and unable to attend), so that no definite conclusion was reached, nor was any one present to answer the questions which were raised in the discussion which followed the reading of the paper by the Secretary. In that report definite recommendations were made and illustrated by sketches for the section of spokes and rim. The different forms of retaining rings most generally used were also illustrated and described. Answering the questions raised during the discussion in the order they are given in the printed proceedings, we would say:

Mr. Brown criticizes the use of lip on the outside of tire. This is used by the Pennsylvania Railroad in connection with their retaining segments, as shown in Fig. 6, by the Canadian Pacific and other roads, and is quite largely used by builders for export locomotives. The object is to prevent the wheel centers from being pushed through the tire in case it becomes loose. By inserting shims from the inside, as stated by Mr. Vaughan, no particular difficulty need be anticipated, and when it is remembered that the frames and other obstructions on the inside cover only a portion of the surface of the wheel, so that below and above the frames it is possible to insert the shims from the inside with but little inconvenience.

Mr. Fowler considered the differences in the hardness of tires and its effect upon the rolling-out action. The usual practice in rolling tires is to use a softer material for passenger tires, medium for freight and very hard for switching. The tensile strength and elongation given in Bulletin No. 14, American Society Testing Materials, is as follows:

SERVICE	DRIVING			Truck and Trailing
	Passenger	Freight	Switching	
Tensile strength per square inch not less than	Lbs. 100,000	Lbs. 110,000	Lbs. 120,000	Lbs. 110,000
Elongation in two inches not less than	Per cent 12	Per cent 10	Per cent 8	Per cent 10

Regarding the use of retaining rings, your committee did not feel justified in recommending any particular form, on account of the great diversity of practice in their use.

Referring to the additional subject which we have been asked to consider, namely, "Distortion of Wheel Centers and Tires Out of Round Due to Heavy Counterbalance," we are of the opinion that this whole question is so involved that it had better be made the subject of a separate committee. A great deal of work has been done in the past investigating the question of flattening of tires other than by sliding, and apart from the flattening action between the spokes which might result from a thin tire in combination with wheel centers having too light sections of spokes and rim, it does not seem to be particularly a matter which need necessarily be discussed with the shrinkage of tires and design of wheel centers.

If the suggestions of your committee are generally adopted for the section of spoke and rim for cast-steel wheel centers, it will result in eliminating any possibility of distortion taking place from the above-named causes, as it will be generally found that wheels made from these suggestions will be much heavier than many designed some years ago, so that the last subject assigned could more properly be taken up and considered by a separate committee, with a view to saving time, which would allow

some definite action to be taken at this year's meeting of the reports which have been submitted for the two previous years.

In conclusion, your committee would renew its recommendations made in 1905 and 1906, and the whole question, if considered advisable by the Association, may then be referred to letter ballot.

F. J. COLE (Chairman),
J. E. MUHLFELD,
W. A. NETTLETON,
D. J. DURRELL,
W. L. TRACY,
Committee.

NEW YORK CITY, May 20, 1907.

MR. A. M. WAITT: Mr. Chairman, I do not recall the report of the committee as presented last year definitely enough to remember whether they took up one of the subjects that Mr. Deems suggested or not — the question of parted or solid rims, and I see they do not refer to that this year. I was greatly interested, in visiting numerous shops and foundries in both England and Germany, to find that the prevailing type of driving-wheel center was one cast solid, no parted rim and fitting of intervening pieces to make the wheel center complete. On inquiry I found that they had no difficulty in doing this successfully. I also was shown in one place a center that had been cut to show that there were no strains which would give a tendency to separate as a result of casting the center solid. In this country it seems to me the prevailing custom still is to use parted rims; in fact, I do not recall recently seeing any solid rim centers. I was wondering what the committee might have found or concluded with regard to that point. For one, I should be very glad to have enlightenment on the subject. It would seem as if when they are successful in casting the wheel centers solid abroad, that we ought to be able to do equally successful work in that line here.

MR. C. A. SELEY (C. R. I. & P. Ry): Mr. President, I think Mr. Waitt was not paying attention to the reading of the report, as the paragraph on the first page says that the committee prefers that the wheel center rims should be uncut, but if necessary to cut them, they should be machined out and closed with solid cast-iron liners driven in. So far as my own observation goes, I

think the practice that we are following at the present time is that the solid rims are used wherever possible.

MR. WAITT: I will confess that I overlooked that one clause, though I had read the report twice.

PROF. H. WADE HIBBARD: Mr. President, I notice in the first paragraph it states that the "shrinkage" should be "1-80th of an inch per foot in diameter for cast-iron and cast-steel centers less than 66 inches in diameter." Then a sudden change is made to 1-60th of an inch shrinkage. I would like to inquire of the committee why that sudden drop there. We do not in other sorts of engineering problems make sudden breaks of that sort. Unless the committee has some reason for varying from the printed data, it would seem the natural thing that the shrinkage should increase in regular progression rather than have a sudden breakage through any change. A center that is 66 inches in diameter has a shrinkage of 1-80th of an inch per foot, but if it happens to be 67 inches in diameter, immediately there is a tremendous increase in the amount of shrinkage. That does not seem to me to be reasonable.

MR. DAVID BROWN (D. L. & W. R. R.): The report refers to the fact that I criticized the use of the lip on the outside of the tire. Having used this extensively, I know the difficulty experienced in shimming the tire from the inside, and with the modern locomotive that difficulty is very much increased. When shimming from the outside, a long liner can be used, but from the inside several short ones must be used, which is not as good a job. By having the lip on the inner edge of the rim of the wheel center, this can be overcome. The shoulders, as I stated, can be 3/8 inch or 1/2 inch wide, and 1/4 inch high. The tire can be recessed accordingly, and shrinkage can be had on this part just as well as any other part of the rim of wheel. The rim of wheel can be same width as the tire — 5 1/2 inches.

Another remark I wish to make is that at the present day we make the rim of the wheel much narrower than we ought to. Take a tire 5 1/2 inches wide; if we can get all of that surface for shrinkage, we are certainly better off than if we can get only two-thirds of it. On our largest rims, in using Mansell rings, the ones that we want to be the most secure, we cut away

¾ inch off each side, and this takes away 1½ inches of our 5½-inch bearing that we could use. Furthermore, we core a great deal of the rim over the pin, probably nearly half of it, and at the opposite part, where the counterbalance weight is, we have a straight surface all the way across. That core, in the other portion of the rim, is about 2 inches wide. That only leaves about 1 inch each side for the shrinkage to impinge on. I think the core should be narrower. We would lose a little weight, certainly, but I think that is the least of the trouble in that case. We should have more surface for the grip of the tire on the rim of the wheel than we have under the present condition.

Mr. Wm. Forsyth: Mr. President, I move that the recommendations of the committee be referred to a letter ballot. (The motion was seconded.)

Mr. Garstang: Mr. President, before that motion is voted on, I would like the committee to say what its recommendations are. I may be a little thickheaded, but I do not quite catch just what they are.

Mr. F. J. Cole: The recommendations are given in the first six paragraphs of the report, and also in the sketches which accompany the report of 1906. The original question that the committee was to discuss was whether the shrinkage on large wheel centers should be increased. We found, after the list of questions was sent out to members, that some were actually using an increase of shrinkage, and there seemed to be more difficulty with the large tires on passenger engines than on smaller engines.

Professor Hibbard asked why there should be an abrupt change in the shrinkage. A few minutes' reflection reveals the fact that, in a general way, the hub is of a constant diameter and does not increase or decrease with the size of the wheel. Therefore it is possible to conceive of a wheel so small that it would be all hub and rim and no spokes. As the wheel increases in size the difference is practically all made up in the spokes and is, consequently, somewhat more elastic, so that it would appear entirely consistent to use the greater shrinkage for the larger wheels.

Mr. Waitt spoke of the parted and solid rims. It is a fact that there are at least three or four foundries in this country that

are willing, and actually prefer, to make wheels with solid rims rather than parted rims, and it seems to me that if they are willing to take care of shrinking strains, and it is all a matter of shrinking strains, the wheel is much better with a solid rim than with a cut rim. The cut rim at best is a makeshift. It has been used in the past because the foundries were not willing to guarantee the wheel. As Mr. Waitt says, they have been making them in England and elsewhere successfully.

Mr. Brown speaks of the lip on the inside. It is a much simpler machine job to put the lip on the outside of the tire. You get a center that is just one straight cut without any offset shoulders or lugs. Regarding the width of the rim, the committee recommended a somewhat wider rim than has been generally used, and there would be no objection to making those solid, except on small engines with very heavy rods and pins. It is often absolutely necessary to core out the rim on the opposite side to the crank pins in order to properly balance the small wheels.

Mr. Garstang: Mr. President, as I understand this committee's work, it is to recommend to this Association a proper shrinkage for tires, and in connection with the shrinkage they dwell on the retaining ring and also on the tire with lip, but I do not find any recommendations from the committee as to which they prefer, the retaining ring or the lip on the tire. It may not have been their duty to make a recommendation to that effect, but I think it is an important point and very nearly as essential as the shrinkage.

The President: The scope of the committee's work was somewhat enlarged last year, if you will recall, Mr. Garstang, and while it does not seem to have made any definite recommendation with reference to the question of the retaining ring versus shoulder of the wheel or tire, perhaps Mr. Cole could say something as to why that was done.

Mr. Cole: The committee made a partial explanation, Mr. President, in one of the paragraphs:

"Regarding the use of retaining rings, your committee did not feel justified in recommending any particular form, on account of the great diversity of practice in their use."

Personally, I feel that the whole matter as to whether retaining rings should be recommended should be taken up by letter ballot and decided by the Association as a whole. That is my personal opinion.

THE PRESIDENT: Do you care to include that in your motion, Mr. Forsyth?

MR. FORSYTH: My idea is that this committee should prepare the letter ballot to include all the recommendations in its report. I think it ought to be instructed to do that, and I will include that in my motion.

THE PRESIDENT: Gentlemen, you have heard the motion, that the recommendations of this committee, including also a recommendation pertaining to the retaining rings as against the shoulder, either on the tire or wheel center, be referred to letter ballot. (Motion carried.)

THE PRESIDENT: The next is the report of the Committee on Locomotive Lubrication, Mr. D. R. MacBain, chairman.

Mr. MacBain presented the following report:

REPORT OF COMMITTEE ON LOCOMOTIVE LUBRICATION.

To the Members:

Your committee having the subject in hand divided it into four heads, as follows:

1. With reference to high steam pressures and superheated steam.
2. How far may we economize in lubrication, both internal and external?
3. The consideration of standard fittings for lubricators.
4. The consideration of sight-feed lubricators versus pumps for internal lubrication.

First: With reference to high steam pressures and superheated steam.

At the 1906 convention, your committee reported that for locomotives with steam pressures as high as 225 pounds, or those using superheated steam, the temperature of which is as high as 600° F., the ordinary valve oil had been found by experience to be quite suitable, and the problem is one of delivering the oil in proper quantities to the places needing it; your committee believes the latter is possible with the modern sight-feed lubricators now in use.

Second: How far may we economize in lubrication, both internal and external?

(a) Internal lubrication:

Internal lubrication should not be stinted in order that an engine may perform its work properly and without undue wear or heating. Dry valves and dry cylinders mean rapid wear of the surfaces of contact in the steam chest and cylinders, also excessive trouble with the valve motion parts.

Too much economy in the use of oil for internal lubrication is apt to result in hot or slipped eccentrics, broken eccentrics, eccentric straps, links, transmission bars, rockers, valve stems, and connection pins, and aside from the increased machine friction, the performance of the engine is affected. Hard-running valves cause a derangement in steam distribution, and worn packing in valve chambers or at rods causes a loss due to leakage.

With the slide-valve locomotive there is not so much danger of these troubles, as the jar of the reverse lever attracts attention to the fact that oil is needed and the engineman will see that the valves are properly lubricated.

With piston-valve locomotives the internal lubrication may be much below the required amount without any indication from the reverse lever, and the cause of the trouble may have been operating a long time before being discovered; in other words, the engineer on a slide-valve engine, even on a small allowance of oil, is more apt to keep the valves supplied with enough oil to prevent hard service to the machine, while with piston-valve engines he is not so able to tell that the valves need oil, and no one knows that the parts have been running too dry until trouble comes through heated bearings and worn or broken parts.

With this in mind, your committee feels that for internal lubrication, 70 miles per pint for large freight locomotives and 80 miles per pint for large passenger locomotives seems to be the amount needed to lubricate properly. The amount to each class depends upon the speed at which the locomotive is running; in bad water districts the oil allowance should be increased about 25 per cent.

(b) External lubrication.

The use of grease on crank pins and driving axles seems to offer the best solution of how to decrease the cost of external lubrication and at the same time secure the best results, and the committee report of last year gave some experiences with 203 locomotives, that grease, as a lubricant, gave results about as follows:

(a) Reduces engine failures due to heated journals and pins.

(b) Reduces cost of lubrication.

(c) Reduces cost of labor incident to inspection, cleaning and renewal of lubrication packing.

(d) Reduces delays incident to oiling.

(e) Reduces cut journals incident to oil lubrication.

(f) Possibly produces a slight increase in machine friction.

In reference to the cost of external lubrication as compared with that of, say, four years ago, your committee believes that the cost per square inch lubricated, or per pound carried, is less with the use of hard grease than when oil was in general use.

Third: Consideration of standard fittings for locomotives.

The 1906 convention referred your committee's recommendations, as shown in the 1906 Proceedings, page 379, Fig. 1, page 380, Figs. 2, 3, 4 and 5, and page 381, Fig. 6, to letter ballot, and they are now standards of the Association.

Fourth: The consideration of sight-feed lubricators versus pumps for internal lubrication.

Your committee is of the opinion that a well-designed sight-feed lubricator, that has pipe connections suitably arranged so as to deliver the oil in the most direct way to the parts needing it, will under present conditions do the work properly. On superheated locomotives it is, we believe, generally conceded that there should be one pipe from the lubricator leading direct to the cylinders and attached to separate plugs near the center, so that the oil fed from the lubricator, for the cylinder, may be properly distributed. The question of location of plugs in the steam chest is one point on which we find considerable difference of opinion; one member of your committee, who has had considerable experience with superheated steam, favors putting the steam chest plugs at the end of the valve chest in preference to attaching the oil pipe to the center of the chest and letting the oil be carried by the steam to the parts where needed; and your committee as a whole believes that the question of locating steam chest connections is one that can be left open and, therefore, do not care to make any recommendations.

D. R. MacBain,
R. D. Smith,
R. F. Kilpatrick,
C. Kyle,
W. O. Thompson,
Committee.

Detroit, Mich., May 25, 1907.

Mr. W. G. Wallace (D. T. & I. R. R.): Mr. President, there is a part of this report that does not seem to be consistent. In one paragraph it states, "with the slide-valve locomotive there is not so much danger of these troubles, as the jar of the reverse lever attracts attention to the fact that oil is needed, and the engineman will see that the valves are properly lubricated." The

paragraph above that states that " too much economy in the use of oil for internal lubrication is apt to result in hot or slipped eccentrics, broken eccentrics, eccentric straps, links, transmission bars," etc. Now, if the piston-valve engine does not require the oil to lubricate the valve that the slide-valve does, it does not seem to me that those two paragraphs agree. I would like to ask the chairman if the percentages of breakages of valve gear is greater with the piston valve than it is with the slide valve, due to the lack of lubrication on the piston valve, the engineer not knowing that the valves are dry by the rattling of the reverse lever.

MR. D. R. MACBAIN (Michigan Central R. R.): In answer to Mr. Wallace's question with regard to that matter, it would be hard to get an accurate comparison as to the number of failures that the piston valve has recorded as against those made by the slide valve, but the idea the committee wishes to convey in this matter is that the wear due to running with less lubrication than ought to be used on a piston-valve engine is detrimental in many ways. It distorts the motion, produces excessive wear on the eccentrics, connecting pins, and bushings. That was the experience your chairman had in following the matter up personally.

MR. E. W. PRATT (C. & N.-W. Ry.): Mr. President, in view of Professor Goss' experiments at Purdue with regard to additional friction from the use of grease, it would seem to me that the committee was very modest in its last observation on the advantages and disadvantages of using grease. I was in hopes that we could hear a little more with regard to the frictional losses on grease. Personally, I am a strong advocate of grease, but I can not get over those figures of Professor Goss without a little compunction of conscience.

MR. W. G. MENZEL (Wis. Cent. R. R.): I believe the question of lubrication of the locomotive is not up to date at all. There is no question but that most any locomotive ought to make eighty miles per pint of valve oil for internal lubrication, if it gets it regularly. If you make your allowance one pint for eighty miles, and are going to use that pint up on the first ten miles, why, it is not enough. I am somewhat interested in automobiles. I find that the automobile manufacturers are away ahead of the loco-

motive builders when it comes to lubrication. Lubrication is taken care of in such a manner that it is furnished regularly whenever the machine is in motion, and does not depend upon the man to start it, or to start the feed whenever he starts his engine. It seems to me that if you are going to get the best results in lubricating a locomotive, you must attempt something on similar lines; that is, have the lubrication begin automatically when the engine starts and continue it regularly. I think the same thing applies also to external lubrication. To get the very best results, we should have something that will work automatically. We are getting very good results from the use of grease. We practically have an automatic lubricator where we use it on driving-box cellars, or on pins. The grease is fed automatically. We are getting splendid results from that. I think that on a good many railroads we would have no end of trouble these days if we were still using oil as a lubricant on pins, with enginemen giving so little attention to the locomotives as they are at the present day. [Applause.]

MR. J. J. THOMAS (Atlantic Coast Line Ry.): Mr. President, one thing I would like to ask the committee is, in regard to the recommendation of the quantity of oil to be used. I would like to ask where the dividing line comes. I am Master Mechanic on a Southern road. On part of our territory, where ordinarily we make runs in eight or nine hours, it has taken as high as twenty to twenty-two hours to make the run. Now, that is what we are up against on our mileage. It appears to me there should be a time limit figured out in some way. We all know if it takes twenty-two hours to go over a division that we ordinarily should go over in eight hours, that necessarily it takes more oil, not only for external lubrication, but also valve oil, and these hard and fast lines, so many miles to the pint, do not work in every instance. It appears to me that the recommendation should include a time limit as well as a distance limit.

MR. MACBAIN: Mr. President, that part of the report is a quotation from last year's report, but in explanation I might say that, even on a division where a trip used to take twelve hours and is now requiring twenty-four, it does not necessarily mean that the locomotive is working twenty-four hours and feed-

ing oil into the cylinders or into the valve chests. It does not help any, as the first pull of the throttle will sweep everything that is in there — oil, water, etc. — out to the atmosphere. The recommendation of the committee, as I understand it, is about seventy miles to the pint for slide-valve engines, twenty by twenty-eight, or larger, and a little more for the extremely large engine, and passenger engine twenty by twenty-six inches and larger.

In speaking of lubrication, I have run a locomotive myself having 17 by 24-inch cylinders, carrying 135 pounds of steam, two hundred miles on a pint of valve oil, and had plenty, but I can not do that with a 21 by 26-inch passenger engine carrying 200 pounds of steam.

MR. D. J. REDDING (P. & L. E. R. R.): I believe that the fourth section of the report of the committee as to the location of plugs in the steam chest is probably one that will stand some very careful investigation.

We had the covers up on those chests several times at the end of a run and found a large quantity of oil down in the inlet passages, and the valve seats perfectly dry. A change in the location of the plug so as to deliver the oil directly on the valve seat did away with that trouble, and I believe it is worth looking into.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): We are all prone to specify the amount of oil to be used on an engine, because it seems to be the only way we have of reaching a limitation with those who are disposed to use oil excessively. I really do not know how far a locomotive will run with a pint of oil if properly handled. I had occasion some time ago to send our Traveling Engineer to review the methods of a certain engineer who had a faculty of making any kind of mileage that he saw fit to make on valve oil, up to 1,000 miles to the pint. The report from the Traveling Engineer was that the man was running a 17 by 24-inch engine in passenger service. He demonstrated to the Traveling Engineer, at least to his satisfaction, that it all lay with the engineer as to what was the requisite and necessary amount of oil for an engine. He showed him that whenever he pulled out from a station without having used his cylinder cocks,

that from that time on it would require forty miles of excessive oiling to have the engine properly lubricated and in good condition. When running the engine himself and nothing unusual occurring on the trip, he frequently run 1,000 miles to a pint of oil, and it was a known fact that such a thing as the reverse lever rattling with his engine was almost an unknown condition; that he could, when running the engine himself and handling it under the methods that he prescribed, unhook and put the latch of the reverse lever between the notches, and it would stay there for miles without moving out of position. [Laughter.]

MR. W. G. WALLACE (Detroit, Toledo & Ironton Ry.): I do not expect to come anywhere near Mr. Manchester's remarks in what I am going to say, but I do believe that the engineer is responsible for the valve oil record. Having run a locomotive, and afterward ridden with this man and tried his experiments, I can verify them to a certain extent. I know an engineer that is running a locomotive on a milk train, picking up cars every few stations, handling a heavy train, an 18-inch cylinder engine, and who fills his lubricator once a week, on Sunday. That is all he has. He will lift that reverse lever out of the latch and hook it up with one hand. I asked him how he did it, and he told me that he never had shut the engine entirely off since he had run it; that when he shuts the engine off, instead of closing the throttle tightly and letting the reverse lever down, he leaves the reverse lever at short cut-off, where it does not pull on the lever, and cracks the throttle joint open sufficiently to prevent a vacuum being formed in the cylinder that brings down the hot smoke and gases into the cylinders, and which destroyed the lubrication. After he had talked with me along these lines I tried that experiment with an engine and I have made 300 and 350 miles to a pint of valve oil, on a 19 by 26 engine, but it is too much work to expect the engineer to do that, and therefore it occurred to me that if we could get something in the line of the drifting throttle, something that would prevent the formation of that vacuum in the cylinders that destroys the lubrication by bringing the hot smoke and gases there, that we would largely overcome the difficulty experienced in lubricating valves and cylinders.

Mr. W. E. Symons (Pioneer Cast Steel Truck Co.): Mr. President, as there is quite a difference in the size of lubricators, I would like to ask the last speaker to state the size of the lubricator which was filled once a week. They range all the way from a pint up to several gallons. [Laughter.]

Mr. Wallace: The ordinary No. 10.

Vice-President McIntosh: There is a well-recorded story going the rounds among old railroad men, of a locomotive engineer on the Michigan Southern road in the early days, who carelessly left out one of the handhole plugs, and made a successful trip. [Laughter.] I expect if we allow further license in this direction, somebody will be telling fish stories. [Laughter.]

Mr. J. H. Setchel: I think Mr. Wallace has struck the keynote in the matter of lubricating cylinders. Much depends on the manner in which the engine is run. In the capacity of a locomotive builder, I was at one time sent to a western road to examine two engines that it was claimed had too light a valve motion. These engines were hauling a fast train, and I was to make a trip on them to locate the trouble. We started out with one of them, the engineer having been informed that the injectors were all right, and we ran sixty miles without stopping, the reverse lever rattling every moment of the time, the engineer apparently paying no attention to the water supply, which was kept at full glass by the fireman. While firing, if the steam got a little low, he turned and shut the injector off. He did all the pumping, the engineer paying no attention to it whatever. That was something new to me, having run an engine many years myself; it was something I always attended to myself; that is, to pump my own engine, and usually enforced it on others when I was Superintendent of Motive Power. The next day I made an attempt to ride on the other engine. I went to the station, and, looking up at the number, I saw it was the same engine. I thought there was no use going down on that engine again, so I waited until the next day and tried the other engine. Presently, when the engineer came around, I saw that it was a different engineer. I introduced myself, told him my business, and we started out, running exactly the same distance and with the same train. He looked over to the fireman and said, "That

injector is all right, is it?" "Yes," said the fireman. "Then shut it off; I will do the pumping," said the engineer. We started, and the water in the glass was always in sight and varied scarcely at all during the trip. The lever moved perfectly easy all the time, and there was no rattling of the reverse lever. That indicated the difference between those two men, on the same class of engine.

I believe it is a fact, however, that the slide valve shows more quickly any defect in oiling than does the piston valve. At the same time there is a damage going on all the time. It is like the "overcoat," it is there, but you do not see it; you are not able to detect it; it does not telegraph to you as quickly as the slide valve. When the slide valve is properly lubricated, it will run for a long distance with a very small quantity of valve oil, and a proper water level is the great secret of using more or less valve oil to do the same work.

In regard to what Mr. Menzel has said about automobiles — I am interested in automobiles, I wish I had a good one — but the great secret of it, especially on the White machine, is the fact that the water supply is constant and automatic and there is no variation in it at all. Therefore a very small amount of lubrication will do the work, and that, in my judgment, is the great secret of using so small quantity of valve oil — a constant low feed of water.

MR. MENZEL: The statement made by Mr. Manchester, that one of his engineers had made in the neighborhood of 1,000 miles with a pint of valve oil, I am inclined to believe is true [laughter], because I have had the same experience. I can give the name, address and all the particulars of a man who made 1,000 miles to a pint of valve oil, not only for one week, or one month, but for a year, and over a year, every month. It simply simmers down to what I said before, to the question of getting the oil with the best possible regularity and handling your water right. A very small amount of oil will lubricate the valves and cylinders if it is not washed away, and, of course, as Mr. Setchel says, in a White steamer you never have high water.

MR. ANGUS SINCLAIR: Mr. President, as there appears to be some doubt concerning the accuracy of the statement of Mr.

Manchester about locomotives running 1,000 miles on a pint of oil, I want to say that I have known a great many locomotives that ran 10,000 miles to a pint of oil [laughter], or rather, I knew that they ran all the time without any oil. When I went into the locomotive service first, when the steam pressure was from 90 to 100 pounds, the steam engineers of Europe held that cylinder lubrication was quite unnecessary; that there was sufficient lubrication in the wet steam to keep the valves and pistons from cutting, and it was a fact that there were no lubricators. I had been firing an engine for three years before I saw the first lubricator put on, and we were by no means pleased when they came, as we had to go out to the front end to oil, the same as they did in this country, and they frowned upon it as a "Yankee invention."

VICE-PRESIDENT McINTOSH: I understand that Mr. Lewis has had some experience in mechanical lubrication, and we would like to have him close the discussion.

MR. W. H. LEWIS (N. & W. Ry.): Mr. President, I am impressed by what has been said here, that the man who tells the first story does not stand any show at all. [Laughter.] To bear out my impression, I want to say that I lately noticed an incident that is not second-hand, but which I saw myself or I would not have believed it. We have as a standard on our road, the piston-valve engine. Some time ago it became necessary to renew the bushings in the valves, or the valve chambers, of one of the piston-valve engines. The engine had run for eighteen months, came into the shop for an overhauling, and it was discovered that during that eighteen months not one drop of oil had entered the steam chest. [Laughter.] In renewing the bushings, the man had failed to drill the oil holes through from the oil plug. One of the cylinders and valves was as smooth as glass, not a scratch in it, and the other cylinder was slightly scratched, but had not worn to exceed 1/8 inch. That shows you, gentlemen, what the possibilities of lubrication are. To be sure that there was no mistake about it, that no oil ever got into the cylinder, I attached the air pressure to the oil plugs, and there was no visible passage between the air plugs and the steam chest. [Applause and laughter.]

MR. MANCHESTER: While I was the one, perhaps, who started this discussion of running long distances without oil, Mr. Lewis has put the cap to the thing, all right, and was right when he said the man that had the first speech did not have any show. I still do not believe that engines should run eighteen months without oil. In making a dynamometer test some time since we ran against a hill and stopped with a pull, as I remember it, of 40,000 or 41,000 pounds on the drawbar, slacked back, but still the entire train was on the same grade all the time. We got some oil into the cylinders and took the train out of there without any change in steam pressure, adding 3,000 pounds to the drawbar pull by getting some oil into the cylinders and getting them all lubricated. So I believe we can afford to have our cylinders lubricated. But I still believe it is possible to have the cylinder lubricated, and lubricated well, with a small amount of oil, if all of the things that may be done by the engineer to add to the lubrication of the cylinder with little oil, are done.

MR. MENZEL: Mr. President, the point I want to make in regard to lubrication is that we can probably give a reason why we are not doing better. One of my engineers who had done very well on oil for a long time suddenly fell off — perhaps not suddenly, but gradually fell off. I took the matter up with him and found out the reason for it. He put it this way: He said that he could run an engine just as light on oil as anybody by giving it very close attention; in fact, watching it all the time, but he found that he was giving practically all his attention to the lubricating of the engine in order to make an oil record. He said he had made up his mind that he would rather pay a dollar, or perhaps $1.50, out of his own pocket, and get more oil, and not watch it so closely. He said if we did not want to let him have the oil he was willing to pay for it rather than to have the extra trouble of watching the oil so closely. I think that is probably the secret of why we are not doing better on oil.

MR. MACBAIN: Mr. President, in closing the discussion, I just wish to reply to some of the questions that were brought up.

With regard to the point that Mr. Pratt raised as to loss due to increased friction, all that I can say is what has been said by others before, that we have not discovered, or have not noticed

yet, that we have had to reduce the rates, or have not noticed any reduction in the speed made on passenger engines, on that account, and in our part of the country, with the service we have to furnish, we feel that that loss due to friction, if there is any, is simply the price we have to pay to get what is demanded of us.

With regard to the point brought up by the gentleman in comparing the automobile to the locomotive, his suggestion just reminded me of something. Everybody agrees that if the oil could be delivered at the right place, at the right moment, very much better results would be obtained from a very small amount. Now, in connection with that I have in mind on our own railroad, I know that our passenger engines, in making a drift of a mile coming into one of the stations, where they have to shut off a mile back, by the time they get down and stop at the water plug, the piston rods are black, the valve stems are smoking, and it is safe to say that the inside of the cylinders and valve chests are black and burned absolutely dry, the few drops of oil dropped in while the engine was shut off and making that drift into the station being burned out immediately. As a matter of fact, instead of starting out of the station with our engine perfectly lubricated, as we ought to have it, for a run of fifty miles or such a matter, we are going out with an engine that is just as dry as we can make it, and we have to make the trip between that and the next station with the same thing repeated, in shutting off and drifting into the station again; the valves and cylinders are again burned dry. With the automobile the lack of drifting cuts out that feature, and that is why, in my estimation, the lubrication is so much better on the automobile than it is on the locomotive.

In regard to the point raised by the gentleman as to the location of the steam chest plugs, we have had considerable experience with that on our line, and we found with one lot of locomotives we had, where the oil pipe was divided and had branches running into the steam rings on each end, we were having trouble. The engines in running 20 or 30 miles with the lubricator feeding plenty would get dry, but the reverse lever frequently pulled out of the quadrant, and went into the corner, and the engineers reported that when they shut the engines off they invariably got a shower of oil from the smokestack back

onto the front windows of the cab. That was not a very satisfactory state of affairs, and we changed those engines. We took the plugs from the end and tapped into the center of the steam chest and simply dropped the oil into the steam cavity, and have had better results since.

THE PRESIDENT: The next paper is by Mr. Cross on "The Apprentice System on the New York Central Lines."

THE SECRETARY: Mr. President, I would like to say that the Executive Committee assigned this as a topical discussion, but Mr. Cross was kind enough to send his remarks to Chicago, and I had them printed and distributed, making it more convenient for the members.

THE APPRENTICE SYSTEM ON THE NEW YORK CENTRAL LINES.

By MR. C. W. CROSS, Supt. Apprentices, and MR. W. B. RUSSELL, Asst. Supt. Apprentices.

To the Members:

The object of this paper is to present briefly the main features of a plan already in successful operation on a large scale which aims to meet a genuine need in a direct and common-sense manner, a plan worked out primarily to meet the specific needs of a particular group of shops, yet based on general principles that will make it workable anywhere.

PURPOSE.—The purpose of the apprentice system is to provide the Motive Power Department with an adequate recruiting system which will eventually produce from the ranks a large number of skilled workmen, a number of foremen, a sufficient number of good draftsmen, a few Master Mechanics and an occasional Superintendent of Motive Power.

The subject of an approved apprentice system has long been a favorite scheme of Mr. J. F. Deems, and was first mentioned by him on the New York Central Lines in December, 1902; it was not until March 1, 1906, however, that arrangements could be made to inaugurate the plan. At that time the authors of this paper were engaged to take charge of the work. The first apprentice class under this plan was started at West Albany Shop May 7, 1906. Much of the general idea and many of the details have been worked out in conformity with the suggestions made in a paper on this subject by Mr. G. M. Basford, read before this Association at the 1905 convention. Mr. Basford expresses the necessity for this work in these words: "The engineering and the operating situation on railroads is in advance of its men, and in many ways the problem has out-

·own both the individual and methods of dealing with the individual, ıd especially has it outstripped methods of preparing men for their ork. . . ."

PLAN — TRADE AND EDUCATIONAL.— The general plan is twofold, and rovides for shop instruction of the apprentice in the trades and also for is instruction in mechanical drawing, practical mathematics and shop roblems during working hours while under pay.

INAUGURATION.—A Department Headquarters was first organized to utline the courses of instruction and to prepare the necessary instruction heets and text-books. Two instructors — a shop instructor and a drawing instructor — were then appointed at each of the larger shops; a niform set of apprentice regulations was adopted for all shops and a chedule provided showing the time allotted in the shop to each class of ork. This schedule is sufficiently flexible to insure a prompt movement f the apprentices from one type of work to another and to still leave pportunity for rapid movement in case of special merit. Both the shop nstructors and the drawing instructors are under the local shop officers nd responsible directly to them. Regular reports are made by both nstructors to their immediate superiors, who forward them to the apprentice headquarters. In the educational work, however, the instructors are ept in direct touch with the Apprentice Department.

DIFFICULTIES.—There are really no serious difficulties, except that of ecuring the thorough and hearty coöperation of everybody in the scheme. The work can not be successful without the enthusiastic support of the dministration and of the local officers. In the inauguration of a plan f this nature the following points are sure to present themselves:

1. The selection of a shop instructor already employed in some apacity at the shop in question, who is preferably an up-to-date all-around machinist competent to give direct instruction in the machinist trade, but with sufficient knowledge of the other trades which may have local apprentices to be able to intelligently supervise apprentices in those trades.

2. The selection of drawing instructors, preferably draftsmen or mechanical engineers, who possess the rare qualities necessary to successully instruct ungraded classes under new and trying conditions.

3. To obtain and equip suitable class-rooms located near the center of the shop property.

4. To secure the hearty coöoperation of shop superintendent, foremen, gang bosses and mechanics who have been trained under a different ystem, and whose coöperation is essential to make such an apprentice ystem a success.

5. To obtain from the average apprentice a proper appreciation of he opportunities offered and an enthusiastic endeavor to make the most of them.

6. To introduce the training system for apprentices in a manner that will not interfere with the operation of the shops.

Present Operation — Extent.—The plan is now in operation at nine of the largest shops of the system, and includes about 450 apprentices. The work is gradually being extended to the smaller shops. The drawing instructor in every instance is a draftsman or mechanical engineer, located either at the shop or a company drafting room close at hand. The shop instructor in most instances holds some other position in the shop in addition to that of apprentice instructor. The apprentices are under the foreman, and responsible to him as formerly, but the foreman is relieved of the duty of instructing them in the trade, thus enabling him to give his full time to directing the work of his department.

Methods.—The work in drawing and shop problems is outlined at the apprentice headquarters at New York city, and sufficient flexibility is allowed to fit the personality of the local instructor and the needs of the local apprentices. The plan of instruction is arranged to give the closest possible connection between the work in the shop and the work in the classroom. In fact, the practical and theoretical parts of the work are so thoroughly united that the grease of the shop is literally rubbed into the lesson sheets and drawing papers. Subjects are not classified as in most school systems, but the necessary mathematics, mechanics, physics and chemistry are introduced only as needed to solve some practical shop problem. The drawing is from actual parts from the start, omitting all exercises and preliminary geometrical work as such, and introducing principles only as needed to gain practical ends. Simple blue-print sketches are used for the drawings in connection with the actual machine parts; printed sheets are supplied for the problems. The shop instructors coöperate with the drawing instructors in looking after the general welfare of the boys. Arrangements are made for the instructors to make occasional visits to other shops to observe methods of instruction. Apprentices are sent to visit other shops and report their observations.

Class Work.— The instruction is largely individual, with classes limited to twenty-four apprentices at once time. By use of the blue-print sketches on which are the necessary directions, it is possible for the instructor to hand an apprentice a sketch and a machine part, thus enabling the apprentice to start at once on the work. This method permits the instructor to keep a class of twenty-four busy, even when each member is working on a different sheet. The first drawings are very simple, so that accuracy may be insisted upon from the start. In order to save time and have corrections made at once, no work is removed from the drawing-board until it receives the instructor's O. K. The work is scaled so that it can not be copied from the sketch and the course is arranged to advance more slowly than usual drawing courses. One principle is introduced at a time, and then only as needed to make an actual car or locomotive drawing. Lettering is an incidental item. The shop problems are usually worked at home on standard sheets, and an occasional blackboard review is given in class. The home work is assigned on loose printed sheets which

makes it possible for an apprentice to go as rapidly as he desires. In the courses that are now used, much that is dear to the mathematician and physicist has been left out. All the work that is introduced is in accordance with the New York Central Lines practice, from which illustrations are selected. A comprehensive system of reports is made by both instructors to the local shop officers. These reports show: First, the ability at the trade; second, the disposition and personality of the apprentice, and, third, the standing in class work. The instructors are at all times required to know the standing of each apprentice, thus making examinations unnecessary. Special emphasis is placed on the personal touch maintained between the instructor and the apprentice, with a view to determining the type of work or branch of service for which the boy is best fitted. It has been found necessary to use great care in selecting instructors, who must be men who are not only competent, but who are willing to undertake the work for the love of it and their interest in the young men, as well as for the remuneration they receive. At the expiration of apprenticeship, those who have satisfactorily completed their term receive certificates which entitle them to preference in employment at all shops on the New York Central Lines.

Hours.— Instruction is given each apprentice four hours a week during shop time; that is, two mornings from 7 to 9 o'clock, and such instruction is all classed under the name of mechanical drawing. Apprentices ring in before coming to class and are under shop discipline during the session. At 9 o'clock they proceed directly to the shop. Home work is expected on the problems. Both instructors are available for consultation during the noon hour.

Facilities.—The facilities for handling work of this nature on a railroad are almost boundless. The authors appreciate the fact that they have only made a beginning thus far and that the apparatus at hand in most railroad shops would rival the outfits of some of the laboratories in the large technical schools. It is possible to have occasional demonstrations in the Company's testing laboratories and to conduct steam consumption tests on locomotives and power plants. Home-made apparatus can be readily constructed or old machines altered to make satisfactory demonstrations of the most useful and fundamental laws of nature, and, better still, the practical applications of these principles can be shown in machines and other appliances on the shop property. The facilities of railroad telegraph, railroad mail, and shop visits by apprentices and instructors, are a few of the special advantages available where several schools are run at once. The concentration of motive power responsibilities of a number of roads under a single general officer renders it possible to inaugurate a much more comprehensive plan than a single road or a number of small roads could attempt.

Attitude of Men.— The rank and file, not excepting the politician, the labor reformer, the practical joker and the workmen of all grades and

peculiarities, unite in giving their approval to a plan, the object of which is to train their own sons in a business that will enable them to gain a livelihood, and possibly advance to a position of authority and responsibility.

INTEREST OF APPRENTICES.— No more interesting study has presented itself than the personality of the average apprentice. On the whole he is below the standard of education and ambition generally presumed by most motive power officers, who naturally think all apprentices possess the same exceptional initiative and earnest endeavor which has brought them up from the ranks. The average apprentice possesses a great deal of human nature; he means well, intends to make the most of his opportunity, generally prefers to be a real boy and to enjoy life, rather than to work problems at home; he will not read a text-book except under compulsion, and has absorbed a little of the idea that the easiest way to become a journeyman is to do as little work as possible. On the whole, however, the interest of the apprentice is good, and is increasing in proportion as the facilities for experimental work are increased and the plan of instruction is extended. There are instances where the boys have kept the local instructors busy in supplying them with work, and it is evident that the ambition of many boys has been aroused and that the right chord has been struck, so that in time the boy without ambition will become a rare article. Reports show that apprentices started during the last year have evidenced a most commendable enthusiasm. On January 1, 1907, there were no less than forty-five letters of commendation from the Superintendent of Apprentices. It might also be interesting to state that at nearly all points there are advanced apprentices who take full charge of classes when the instructors are absent.

EFFECT ON APPRENTICES.—The effect upon the apprentices has already been awakened interest and marked improvement in skill in the shop, ability to read drawings, ability to lay out templates, and in several cases skill in drafting sufficient to warrant assignment to the drafting room for sixty-day intervals.

EFFECT UPON OUTPUT.— It is difficult to determine exactly the effect upon output. The time spent in class, four hours per week, would appear to cause a slight decrease, but this is more than offset by the increased skill of the apprentices due to the presence of the shop instructor to make each machine count, even with a green apprentice. It should be understood that all of the work done by the apprentices is on the regular shop machines and forms a part of the shop output.

EFFECT UPON MEN.—A feeling among the men that perhaps the apprentices would outdo them has been met by the organization of evening classes for foremen and mechanics at seven shops, taught by the drawing instructors of the apprentice department. The finances of these classes are handled by the instructors, while the Company provides the use of the room, light and heat, and gives the men the benefit of the courses

provided for the apprentices, with the slight changes necessary to suit the conditions of the evening classes. The men provide all their own materials and drawing instruments. The classes are run either once or twice a week for two-hour periods, either directly after working hours or in the evening. While the total enrollment was but 150 this year, it nevertheless expresses the general feeling among the leading men in each shop. The result has already been a closer intimacy on the part of the shop men with the shop draftsmen and with company standards.

Effect upon Instructors.—The effect upon the instructors themselves has been most pleasing. Without exception, they have developed, not only as enthusiastic instructors, but also in all-around ability. The exigencies of teaching have brought them in contact with many features of the service previously overlooked and the occasional observation trips and interchange of ideas have already made them more valuable to the service. Many valuable suggestions have been received from the instructors and adopted.

Treatment of Apprentices After Graduation.— Perhaps as vital as any other principle is the necessity for caring for graduates with infinite pains after they have completed their apprentice terms. The results of the best possible apprentice system may be absolutely nullified if the organization into which the graduates are to go is not properly prepared to receive them. It is not too much to say that most railroads and most large industrial establishments need to put their organization in such order as will render not only employment desirable, but advancement possible. As an incentive to all and a reward to the especially studious and proficient, it is desirable to give a limited number of those showing the best records a prize in the way of a more advanced course at a technical school at the expense of the railroad; the young man to work in the shops during vacation time, thus retaining his close relationship to the work.

Probable Results.— It will undoubtedly take years to show the full value of the apprentice system. Already draftsmen are being provided for the Company drafting rooms, and New York Central standards are becoming familiar to all apprentices. In the future every journeyman will be able to read drawings and make working sketches. Men will show greater pride in their local shop and increased loyalty to the Company, and the tendency to resign their positions for work with other companies will be lessened. It is not expected that all of the boys will attain a degree of efficiency that will qualify them for leadership, or that all workmen will possess the same measure of ability and activity, on account of the difference in their natural intellectual and physical qualifications, but it is expected that each will be developed to a high degree in his particular line, with the result that eventually each shop will be manned by a force of mechanics embodying an advanced state of proficiency from which at least a few competent men may be had at all times for positions of leadership.

Attitude of Other Roads.— The criticism has been made that the New York Central Lines is educating apprentices for other roads, and

the statement is to some extent true at present. The awakening of interest, however, in industrial education, and the inquiries and observations from all directions, indicate that other railroads are now giving this matter the consideration it deserves, and in some instances have taken action with a view to inaugurating some part of the plan proposed. The fact is being appreciated that no outside system of instruction, such as trade schools, correspondence schools, or even Y. M. C. A., can fully meet the needs of the apprentice, and that the control and direction of the instruction must be coincident with the control and direction of the shop. The indications point to a day not far distant when each railroad will have a fully equipped apprentice system organized as an integral part of its Motive Power Department. Before such work can start, the management must be convinced that for its own safety in the future it must be provided with skilled, intelligent native workmen; men who can stand on their own merits and do the work which is needed to keep this country commercially ahead of the world; men who need hide behind no organization to command the respect of their employers; men who can and will bring skill and judgment to their work so that they may command compensation commensurate with their increased ability.

THE PRESIDENT: If there are no objections, the paper will be considered as accepted and open for discussion.

MR. A. M. WAITT: Mr. President, it seems to me very fortunate for the Association that what was originally outlined as a subject for topical discussion has been made the subject of an individual paper and presented in the shape in which it will attract the more attention that it deserves, and will be more carefully studied and read. It seems to me at the present time there is no more serious problem confronting the railroads, and especially the mechanical department of railroads, than the future relationship between the employees in the mechanical department and the companies. We find that probably as much of the time of motive power officers is taken up in considering the difficulties of the labor problem as is devoted to the strictly technical subjects of the department. The growing tendency to specialization seems to have led to a lack of general all-around mechanics in the shops, and it has been noticed in probably every shop in the country that there is a great dearth of suitable men, when a good man is desired for a foreman, and the man in charge of the shops, or of the department, looks about to find a man of the right caliber and a man who has enough of general information on his department work to be put in charge of men. That problem has to be

faced, and it seems to me that this step that has been taken by the New York Central Lines, on a comprehensive and broad scale, is one of the most important moves that has been made by railroads in this country for a long time. Especially it seems to me fortunate that the New York Central people should be willing to make public, even in the early days of their apprenticeship system, what they are doing, what they are contemplating, and the methods by which they expect to produce greater results in the future than they have in the one year in which the system has been in operation. I was very much interested since coming here to see that as a supplement to the paper prepared by Mr. Cross the *American Engineer* had published a lengthy article, which it would appear is going to be one of many, outlining in detail the system that is inaugurated on the New York Central Lines, in connection with their apprentices. I read that somewhat hastily, but with a great deal of interest, and I believe it can be read with profit by every gentleman who is present at the convention, for I think there is nothing more important for the future good of railroads, in the mechanical department, for raising the standard of mechanics in the shops, than the establishment of a thoroughly comprehensive and wisely carried out system for educating apprentices, so that we can, as I said before, have all-around mechanics and not men who simply know one little specialty and take no interest outside of that.

There has been a tendency lately, in connection with various organizations, to seemingly lower the standard of efficiency of the men. I believe that a system such as has been outlined by Mr. Cross is one of the steps to offset that tendency and raise the standard permanently for the future, as it should be raised, so that instead of going through our shops and comparing the present class of men with those of fifteen or twenty years ago, and commenting as we do now that they are not up to the old standard, that we may in five or ten years from now look through the shops and find the standard constantly improving, and so that others may look to the railroads as an example of the best methods of raising the caliber and the general standard of mechanics.

In the past we have had numerous papers, reports and discus-

sions on the subject of apprentices, and we have in fact in the Recommended Practices of the Association an outline, somewhat crude, of a plan for instructing apprentices in the shops. It seemed to me, as I read that over recently, and in view of the paper that is presented now and the discussion that will no doubt follow, that perhaps it is a little out of date, and I question whether or not the Executive Committee may not find it worth while to look it over and see if it should not, for the time being at least, be eliminated from our Recommended Practice, so that we can take up the advanced step that has been presented to-day, and which can be followed up by the detail just mentioned, in the article in the *American Engineer*.

There is one more thought that has come to me in connection with apprentices and with training them. There is a common tendency in shops for general foremen to feel that they must, in taking young fellows into the shop for training eventually to become mechanics, get all that they can out of them — to get all the value possible at first from their services, forgetting that one of the desirable features in training apprentices is to make them first-class workmen. The value can not always come in the first years of their apprenticeship, but just as surely as they are properly trained, the value will come to the company and to the community at large from their services after they have been properly trained, and I think we should not forget to make the proper training of the young men the first consideration, and the getting the value of their services in the first years of their apprenticeship secondary. Surely the best results will come in the end by carrying out this principle.

There is a great deal that I could say on this subject, but I know there are others who will be only too glad to express their thoughts and their endorsement of the work that Mr. Cross has outlined, and I am sure the Association feels indebted to Mr. Cross for presenting this paper in the magnificent way in which he has done it. [Applause.]

MR. J. A. PILCHER (N. & W. Ry.): In connection with the apprenticeship question, the Norfolk & Western Railway has a system of allowing the shop apprentice a certain amount of time in the drafting room. That has been carried on for several years,

with the result that our most efficient draftsmen are men we have secured from the shops originally as apprentices. In several instances where men did not develop just the talent we would have liked for the drafting room they have gone back to the shops, and later on I find some were made gang foremen. Several instances of this kind developed, and I simply bring it to your attention to emphasize the suggestions brought out in the paper just read and to show that, even if entered into to a small extent, this system is beneficial to the service.

MR. H. EMERSON (American Loco. Co.): I think all those who have had to do with labor in railroad shops have felt very much the need of providing some method of training which will develop the future workers in those shops, and therefore they will welcome this magnificent educational work on the New York Central Railroad. On the Santa Fe I have felt that need, because we had there nothing that could be called an apprenticeship system. We had the old method of taking in apprentices, of getting what we could out of them, and getting what assistance in education we could through classes of the Y. M. C. A.

We have, however, been fortunate in being able to check up the work of the apprentices, the work they were actually doing against what they ought to do, and I think it might be of interest to give this meeting a statement of what apprentices under the old system were doing, and perhaps some time in the future it may be possible to find out what they are doing under the new systems advocated to-day. In the boiler shop we had twenty-three apprentices whose average efficiency was 87 per cent. The efficiency of the whole shop, including the apprentices, was 94 per cent, so that the apprentices as a rule were below the efficiency of the men. On the list I find one apprentice with an efficiency of 136 per cent, and another with an efficiency of only 43 per cent. Coming to the machine shop there are fifty-six apprentices with an average efficiency of only 69 per cent. The first man on the list has an efficiency of 136.8 per cent, the next man an efficiency of only 33 per cent, showing the tremendous variation in individuals. The first man is four times as good as the second man, and my impression is that throughout life he will steadily gain, as time goes on, and he will not be only four times as good, but

ultimately ten or twenty or one hundred times as good. The efficiency of apprentices throughout their course of service should be a matter of continuous record, so as to encourage those who show a high degree of efficiency and divert those who show no ability into other walks of life. During the time of apprenticeship, more than at any other period of life, it seems to be necessary to impress upon the apprentice the question of his own efficiency; that what he is learning is not simply to absorb a certain amount of knowledge, but to carry it into actual work so that he himself becomes efficient.

Mr. D. R. MacBain (Mich. Cent. Ry.): Speaking for the Michigan Central Railway on the value of apprenticeship schools as they are established at the present time, I desire to make a few remarks with regard to a few facts as I have observed them. While the system has been in force only a little over a year, the results so far are very gratifying and the conditions are bettering all the time. We found when we were trying to carry out our old system of apprenticeship work, when we undertook to have the apprentices attend a course of instruction for an hour or an hour and a half after the work of the day, we found that we got little results out of that practice — the boys did not put the enthusiasm into the work which they are doing now.

We find also since the inauguration of the new system, and particularly within the last five or six months, since the thing has become advertised to a considerable extent, that we are getting applications from a much better class of young men than before. It is not an uncommon thing for me to be rung up at my home in the evening by some lady or business man, or some one else in the city, making an application for the employment of a son or some other young man in whom they are interested. They have learned and understand now that the apprenticeship system gives them a fairly good technical education if they follow it through. For that reason the applications are very numerous and they are many more than we can take care of. I have found that it is about as Mr. Cross puts it in his paper; that we get applications from all ranks of life, and in the town I am situated in I am not left alone by the politicians or any one else who has a boy

they wish to place. Many of the best people are making application for positions for their sons in the shops.

One other point touched on in Mr. Cross' paper is the attitude of other roads. I wish to say in regard to that part of the paper that I believe a more liberal treatment of the boys after they have finished their apprenticeship will be necessary. We have in the last two or three years broke away from the old practice of increasing the boys 25 cents a year after the apprenticeship, and instead of that have been governed by the recommendations of the machine foremen and general foremen and others, and in many instances we have jumped the boy from the apprenticeship rate 75 cents. The result of that is we are saving to the Michigan Central Railroad men whom we believe in many instances are superior to the "first-class journeyman" that comes around and hires out with you. We have stopped the loss of the boys by pursuing that policy. I will also state that within the last three months two of our apprentices who took up this work when the system was inaugurated a year ago have been called into the mechanical engineer's office. One is in Mr. Gilbert's office in New York and doing well, I am told, and another was called into Mr. MacRae's office in Detroit.

PROF. H. WADE HIBBARD (Cornell University): In the absence of Professor Goss, to whom I would much prefer to listen rather than to speak myself, I suppose I am the only man in the room engaged in the professional business of education. When the author of this paper wrote to me, and asked me if I would say something, I pondered long as to what I should say, and I am not sure that I know now that what I am going to say is what I would say when I think about this a year from now.

It strikes me that the bare fact of the establishment of this course of education for apprentices is as severe an arraignment as I have ever heard of public school education, in the year of Grace 1907. I believe it has been rather generally conceded throughout the world that education is the business of the State, of the community, to be supported by public taxation. Evidently, in this matter, the State has failed, and into the breach has stepped this railroad, and perhaps other railroads, which have followed this example. Not everything is best in this country of

ours. I have been an American through my ancestors for nearly three hundred years, and have a right to criticize my own country. We have to look only at Germany, of all the countries on the globe, in my opinion, for the greatest advance in education, and the experiences that they have had and are now having has developed a line of education that has to-day placed Germany head and shoulders above all other countries. I am not speaking about Japan — I do not know so much about Japan, but Germany is ahead of all other western countries in competing for the world's business, and any quantity of things that you and I buy and our families buy and our children buy and the public buys have upon them the stamp "Made in Germany."

The trade schools of Germany have taken a position in educational matters in Germany that is practically unknown in the United States. I hope that the influence of this paper and the influence of the New York Central Lines in the progress that they are making and will make in this regard will stir up our public school educators so that something will be done to put us on a par with Germany's manual education, training education and manufacturing education.

I thought to myself when the author of the paper wrote me to speak on it that I should not say anything unless I was posted on what had been done in this regard, the successes and failures of the apprenticeship movement as exemplified on the Norfolk & Western Railway, Baltimore & Ohio Railroad, etc., but if we should wait until we know all that is to be known on some question before we say anything about it, none of us would ever say anything at all.

We welcome in the educational movement in this country the work of the correspondence schools, the work of the Y. M. C. A. and all similar undertakings. I remember in my own shop apprenticeship in a locomotive works, that I put in my evenings at classes in the Y. M. C. A., drawing and mathematical work, and I can not tell you how much that meant to me in helping me to get more out of my apprenticeship, but that should be the work of the public schools. The public schools did something in the way of night instruction, in the city in which I was learning my trade, but nothing in the line that I desired to be posted upon.

There was no drawing, no descriptive geometry courses, nothing that would help me as a shop apprentice, and I had to go to the Y. M. C. A. and pay my own money for that which the State should have furnished me free. The correspondence school courses have an excellent place in our system of education, but they lack in the enthusiasm that comes from united class work; and while I have everything of praise to say for the work as outlined by this paper, there may be some points that would occur to me as a professor in an educational institution that we would need to look out for in our system of education. We find in an engineering college that a very great deal of good comes to us from the opportunity we have in a faculty of, say, fifty engineering professors and instructors in the one engineering college where I am, to discuss things together. We have our faculty meetings and discuss matters of educational policy, but more than that, we drop into each other's offices, sometimes into each other's schoolrooms — although that is not as frequent as we would wish it were — and we discuss the methods which we are pursuing and gain advantage from each other's experiences. Furthermore, the professors in the later stages of the engineering course oftentimes are a spur to the professors in the earlier stages in that they shall do the work of a certain character which shall better prepare the students for the later work. For instance, I teach only those engaged in the senior course of railway and mechanical engineering — excuse me for the personal reference, but I know more about what I am doing than other people, of course — and when a professor engaged in freshman or sophomore engineering work sends a boy up to me for senior work very poorly prepared, while, of course, I am careful not to make a criticism which may hurt the other man's feelings, yet it comes out in the course of office conversation or on the campus, or while at the club at meals, that such and such a course might be looked after more sharply. For example, we have just passed through a sort of reconstruction of our engineering and railway work in the college, and we had the professor of junior steam machinery before us, and we talked over his subjects, not in adverse criticism — he welcomed the conference — but we had to talk with him that we might consult with him about certain things in his course. The result of the conference was that we

gave him one-third more time in his junior course, one-third more time than he had been having, and we told him what we wanted to put into that time to brace up the course and let the boys come to the senior year better prepared for the studies in the senior grades. It strikes me as the New York Central has its meetings of motive-power officials at various periods, that the superintendents of the apprenticeship instruction courses might as often or oftener hold meetings of men engaged in this work of instruction, that they may come together and talk over the subjects, some of which could be outlined beforehand, and some of which could be brought up on the spur of the moment, that are necessary for the continued progress and the excellence of their work. It will be necessary for the students — I will call them students, because that is what we call our scholars — that the students in the apprenticeship course should be aided in every way so that the enthusiasm in the courses may be kept up. A new thing is attractive, but when the novelty is worn off the attractiveness diminishes and the enthusiasm begins to wane. It strikes me that special effort should be concentrated upon this, as in other matters of the course, to keep the enthusiasm all through the line — enthusiasm of instructors and the enthusiasm of the apprentice boys.

Now, with regard to the instructors — I do not want to knock these in the least — I so heartily approve of the entire system that there is not much which can be said in criticism of it, but if you will bear with me for a moment I wish to make a suggestion, and that is, the danger which may come from the men who are doing the instructing in the different shops leaving the service of the company, being promoted, having duties placed upon them inconsistent with the carrying out of the duties they are now carrying out in the apprenticeship instruction work, etc. Of course, in our university work we have professors who leave the college, but there is so concentrated an interest by having a large number of instructors in one faculty that the purpose of instructive work as a continuity, even though one or two professors occasionally leave, is not broken. There is a sufficient number left so that there is a continuity of purpose and continuity of enthusiasm, and the students lose comparatively little by the changes of the instructing force.

Finally, it strikes me that perhaps the most important point that the author of the paper spoke of is what is going to be done with the apprentices when they get through with their course of study? There are several Superintendents of Motive Power in this room who have written to me with regard to the duty of the official to attend to the subject of personnel, of promotion, in each department of his shop. Not all Superintendents of Motive Power consider it is an exceedingly large part of their duty to provide for the future, to raise up a personnel in the shop so that they may have a certain man or men ready to step into another man's place, if that man should be struck by lightning — the lightning of promotion, or going somewhere else — actual death or whatever it may be, so that they may have prepared an understudy — one of the gentlemen here used that term in his letter to me — they do not consider the importance of having an understudy, which is a theatrical phrase to describe a person or performer ready to step into the position or part which another person is already filling. That sort of attention to the future of the men who are receiving this kind of education, the men who give their energy and influence into the railroad service, that is, I believe — an exceedingly important portion of the duty of the Superintendent of Motive Power, as important as any other detail connected with the shop.

Mr. Eugene Chamberlin (N. Y. Central Lines): The author of this valuable paper has requested the speaker to make a few remarks thereon, but you will appreciate that one who attempts to follow in discussion such an eminent educator as Professor Hibbard, who in his remarks covered the ground so admirably, undertakes a difficult task, and it is quite impossible for one to add anything to what Professor Hibbard has said. However, in compliance with the request of the author of this paper and also to confirm the remarks of Mr. MacBain (the gentleman from the Michigan Central road), I would state that what he said occurs upon his road, I am aware, from personal observation, is occurring on all of the roads in the System, and the benefits accruing to young men are of a character which seem to fully confirm the wisdom of the undertaking.

Gentlemen, most of us have served our time at some trade;

many have been apprentices, and we know the difficulties we have had to overcome in becoming masters of our trade. Were you to see upon the New York Central Lines, as a whole, the eagerness displayed, also the ambition these young men have to better their conditions through the privileges afforded at the expense of the New York Central Lines, I feel that you would marvel, indeed, and concur in its effectiveness.

Professor Hibbard has said that the "German States have at State expense instituted a very liberal system for the education of the young, for the purpose of making them desirable and independent citizens." I would submit to you, gentlemen, that the attitude of Germany is worthy of emulation by any country, and that such education would correct in a measure the attitude of the public toward railways as well as other corporate interests, which have been such a prominent factor in the development and settlement of this great country of ours.

A reference has been made to the success attained by the young through the agency of correspondence schools. Too much credit can not be given for the great good that such schools are accomplishing, but with all deference to them, it would possibly be admitted that there are a few things that can not be successfully acquired at long range; for instance, teaching the young how to walk. To perform this feat successfully the infant requires some physical assistance. Again, many of us would hesitate before entering an automobile if we were expected to ride at great speed under the guidance of a chauffeur who had acquired his entire knowledge of the operation of the machine by correspondence only.

As a rule, the young man of to-day is "from Missouri," and asks to be shown.

Criticism is made that the New York Central Lines is educating its apprentices for the use of other roads, and this statement, to some extent, seems true. If it be true, then the action of the New York Central Lines is certainly worthy of consideration by all of the railroads in the United States, with a view of having the latter in fairness assume their portion of the burden, a practice that would be fully in accord with the remarks of our honored President in his address this morning, "that railroad

corporations were taking up the duties of the education of its employees and carrying it on as intelligently as possible."

The scheme outlined in the paper presented by Mr. Cross is quite certain to bring abundant results; possibly not in your time or mine may the acme of excellence be reached, but the ultimate results of this grand work of education undertaken by railway companies are as sure as it is sure that the sun rises in the east.

MR. R. D. SMITH (L. S. & M. S. Ry.): The time laid out by the Executive Committee for the discussion of this paper has expired, but in view of the interest developed in the discussion I would move that further discussion be deferred until to-morrow and the noon-hour time be taken for the further discussion of the paper.

MR. J. H. SETCHEL: Mr. President, I have been greatly interested in this paper and it seems to me that the scheme of the New York Central which has been outlined in the paper would supply what we have often felt the want of, skilled mechanics for supervision. It was only a short time ago that a Master Mechanic made an inquiry of a brother Master Mechanic as to whether he could get for him an employee in a certain position. He described what he wanted, and the man of whom the query was made said: "I will hunt for such a man for you, but I want the first man of that kind for myself."

We find that all over the country there is a lack of skilled men for these positions. What the paper which is under consideration describes is the making of captains of supervision; they are the men that are going to get the work. We must have supervision or else labor will do nothing. Labor that is not supervised drops continually until it gets to be worthless. It is the experience of every Superintendent of Motive Power in this country that there are certain lines of work — I might say more particularly in the manufacturing interests of the country, in locomotive works, for instance — that they can take a man and make a specialist of him, and do more work with him than they can under any other system, simply because he does not want to do anything else, and he learns to do that particular work and does it with profit and will turn out more work in the manufacture of locomotives on a given machine than any man educated with supervision. We must

have the supervision first, but must we not have something of the old system of apprentices also? Take men who will do a certain kind of work and do it willingly, and be supervised by these educated men. For years it has been the practice of some railroads to make special apprentices. Many of the supervising officers are men who have been put into the shop and worked a certain length of time in the paint shop, for instance, learned how the ground work should be prepared, and how the work should be finished, and then have gone into other shops. I know of such men who are Superintendents of Motive Power. We must not ignore entirely the subject of taking men from the lower classes of workers. Our country is filled with such people, and do we not owe them a duty to give them this work and allow them to be continued in doing this work? If this suggestion that has been made in regard to the apprentices is followed up by all the roads in the country, what shall we do with these men? We may have higher positions for nearly all these educated young men, but they would not be contented to do a laborer's work — drive a lathe, for instance — because they have not learned to do it properly. You can get a good laborer, and in three months could teach him to turn more tires than could any supervising apprentice.

In my experience as superintendent of the Brooks Locomotive Works, when a committee of young men came to me and said, for instance, "We have been running this shaper for so many months; we can do as much work on the shaper as any one else, but we would like to have another machine;" another delegation of young men want another machine, and others who have been engaged on floor work will desire to be put on machine work. I had to tell these young men this: "The Brooks Locomotive Works is manufacturing locomotives for profit. If we take you and teach you so that you can run a special machine so as to be profitable to us, then you are useful; but if we put you on another machine where you are not as profitable, and put another man on your machine, we make two low-capacity machines. Don't you see that the management could not justify thus reducing the capacity of our machines?

It seems to me, as has been stated, the prime need of the

country is supervision. The New York Central plan seems to provide for that, but we must have other classes of men coming into our shops where we are manufacturing for profit, and the railroads are going into that as fast as they can. Some railroads have adopted a piecework system and it is going to be generally adopted, and it is the best way of getting the most out of your men for themselves and the most out of your plant.

Mr. Wm. McIntosh (C. R. R. of N. J.): I think the failure of the old methods of apprenticeship development is largely owing to the difficulties in securing good material in proximity to the cities. In country districts where the manufacturing opportunities are limited and the variety of occupations that can be reached are not numerous, young men are more anxious to seek employment in mechanical positions, and especially with railroads. When we reach the proximity of the big cities, there are so many varieties of employment and there are so many influences that affect young lads who are seeking employment, that it is difficult to get them to settle down to the regular apprenticeship, and the quality of the help in that direction is of very much lower grade in such vicinities than in country places. Therefore it requires greater inducement to make such work attractive and a greater effort to develop such young men when employed. Mr. Deems has undoubtedly struck the keynote in the system that is being adopted on the New York Central Lines, and there has evidently been a great deal accomplished in the short time that this work has been under way. In former methods of apprentice instruction the effort has always been made to give the boys instruction outside of the regular working hours, expecting them to go back to the works after the regular hours and devote considerable time at night to instructions. It is not surprising that it did not prove successful, for the reason that very few of us who have passed the apprenticeship period would be willing to put in additional hours in that manner if we could avoid it. Therefore the plan adopted to give instructions during regular working hours is one of the most important features of the system and the one that is absolutely necessary to make it successful.

The road with which I am connected is interested in improving the apprenticeship system by methods of instruction quite

similar. Some time ago, in 1905, we established a school in connection with our Elizabethport shop very much on the lines described as in operation on the New York Central, and I want to give due credit to Mr. G. M. Basford for the effort that he put forth in the way of inducing railroad people to take up this plan of instruction. It was largely in following his articles in this connection that our people were induced to adopt the scheme. We have had a school in operation since October, 1905, with a great deal of success. I believe we have sixty scholars under instruction at present, and some of the apprentices are advancing rapidly, so much so that I do not think the New York Central need fear having to lose all the graduate apprentices, for we will be able, in proportion to the size of road, to reciprocate to a modest extent. I will not attempt to say anything further in this connection at present, except that our experience has been most satisfactory, and I feel confident that other lines will rapidly take up these plans and there will undoubtedly develop such a system for the instruction of apprentices as will redound to the general benefit of all the railroads.

Mr. B. P. Flory (C. R. R. of N. J.) (communicated):

The apprentice school on the Central Railroad of New Jersey was started in October, 1905, and has been in successful operation for two years.

We have about sixty apprentices at Elizabethport, and they are divided into three classes of twenty each. The hours of instruction are from 12:45, just after the noon hour, until 2:45, the boys getting paid for the time spent in school.

The classes are held on Monday, Wednesday and Friday, the Monday class being considered the class farthest advanced and consisting of boys in their third or fourth year of apprenticeship.

The classes are under the instruction of the chief draftsman of the motive power department, who is a practical mechanic as well as a technical man.

Regarding the statement made that the New York Central was the first road to instruct each boy individually, I would say that is what we have done since the starting of our school. We have apprentices from the car department, machine and erecting

shop, and try to give each boy some study or duty on the same kind of work which he is doing in the shop.

Our general scheme is just about the same as that of the New York Central, in that we use no text-books, drawings being made from models or sketches.

When we started our school we found a large number of boys with very little education, and decided that any new apprentices which were taken on should have to pass an examination in reading, writing and arithmetic, the questions being simple, but still hard enough to keep out an undesirable element. To show that we have succeeded, I would state that we now have twenty apprentices in service less than six months; ten between six months and one year, and seventeen in their second year.

At Elizabethport our shops are situated near other large manufacturing plants, and we had trouble heretofore in keeping boys after completing their apprenticeship, as they could go to these other places and get better wages than we had given. This we have changed, and now when a boy completes his apprenticeship he gets a substantial raise in wages.

During the first year of our school, five boys completed their apprenticeship and three are still in the service of the company. During the second year sixteen completed their apprenticeship, and thirteen are still in our employ.

During the first year twenty-two apprentices resigned, their services being from two and a half months to two and a half years.

During the second year only fourteen resigned, ten of these being in service about four months.

These figures go to show that we are developing a better class of men, and we have no doubt but that we can hold the boys after completing their apprenticeship.

We are now taking boys in their second or third year and letting the brightest ones come into the motive power drafting room for three months, and then they go back to the shop to finish their time.

The results we get are that it takes less time for apprentices to read drawings in the shop, and consequently they can turn out work more quickly. Shop sketches are made by boys, thus saving

the need of a shop draftsman, or the sending out of one from the regular drawing room.

We have also taken one boy who completed his apprenticeship into our drawing room, and find his services much better than we could get outside for the same money.

There is no doubt in our minds but that we are on the right track and that results will show better and better every year.

Mr. Angus Sinclair: Having been requested by Mr. Cross to discuss this paper, I have given it a good deal of attention, and I certainly have been very favorably impressed with the excellent plans adopted and by the great generosity displayed by the New York Central people in encouraging their apprentices to go into the educational course which they are following. I am one of the men who have suffered from the want of good early education, and I have always been striving to make up for what I ought to have had at school, and on that account I have paid a great deal of attention to efforts of self instruction or efforts at mutual instruction which have been going on in any of the railroad shops. My greatest difficulty has been in keeping this interest up to the mark. The students will come and attend the classes for a few weeks, or a few nights, and then they get weary of well-doing and they lose interest in the thing, and the ordinary apprentice educational system is a failure.

The important part of this thing to me is the way the New York Central people have succeeded in keeping up the interest of the men in these classes. The fact is that the education of apprentices is not a commercial part of the business — it does not come in with making the most out of your plant; I have seen night schools and educational establishments started in connection with industrial places, and the foremen would get very indifferent about encouraging the apprentices, so that the thing was considered a nuisance, and these fellows ought to be kept making the best of their work and put at the work they are most adapted for. The general impression has been that they did not want to put these boys at the things they preferred, or have the system of education selected for them. The theory was — we want to put them where they will turn out the most work, and that spirit which has manifested itself all through the educational

work in this country is likely at all times to represent the best intentions of beneficent companies. It is not a case of beneficence, this work of the New York Central, and I hope the railroad companies will see that it is a case of self-protection for the future that they cultivate the spirit of ambition in their apprentices and educate them so that they will be turned out into the best quality of workmen that it is possible for skill, ambition and intelligence to bring forth.

MR. LEGRAND PARISH (L. S. & M. S. Ry.): This method of instructing apprentices is a good, sound business proposition, with no theory in it. We have found that, by placing an instructor in the shops to instruct the boys, we get a much greater output. We are not losing anything in the matter of dollars and cents, and from a financial point of view we are the gainer. I have also found, in discussing this matter a short time ago with a committee of our machinists, they expressed themselves as delighted with the system, and in fact gave me concessions in connection with the number of apprentices, which was very interesting, showing conclusively that the workmen in the shops are in thorough sympathy with the plan, which is the most important thing we have to consider.

MR. G. L. FOWLER: I want to emphasize what has been said, and disagree most heartily with the insinuation that this system of apprenticeship will not make workmen. I do not think human nature changes very much, and we know perfectly well that with the old system of apprenticeship, where the apprentice was bound out, they made good workmen and that those men attended to their work throughout the balance of their lives. I have seen shops run on the system outlined here where the man was put on a tool, and after running it three or four days he would become expert, and he was expert on that tool so long as it ran all right, but let anything happen — give him an axle to turn back, and have it develop a lot of sand holes, or let a bad spot occur in his tool, and he is absolutely lost, and there is more time spent in getting him straightened out again than a good workman would be put to on ten such occasions. I knew of a whole shop run on that principle. They had one man who could do more work on axles and tires than any other man I ever saw in my life, in any

shop, but there was not a skilled workman in the whole shop from start to finish. They could turn axles and bore tires, but send them in some tires that were hard, or some wheels that had bad spots, and they were lost. They would use up every tool and could not do anything, and on one large job they threw it out entirely, simply because they did not know how to sharpen the tools to do the work, so it was sent to a small country job shop where the owner knew how to do his work and it was finished there. Of course, when you are educating men of this kind at first there will be a demand by them for responsible positions, but after the demand has been fulfilled these men not only will take the positions in the shop which are open to them, and do their work, but they will do it one hundred per cent better, and do more of it. I was assured yesterday by the author of the paper that the arrangement of the New York Central is not by any means a benevolent institution; it is pure business from start to finish, and the statement has been made that is gratifying, that the boys are doing more work in their shortened hours than they usually do in the whole work of the day without the instruction which they are now getting.

Mr. L. R. Pomeroy (General Electric Co.): It seems to me that this plan has in itself the elements of success, because it is not philanthropy, but business.

Mr. Setchel mentioned one of the disadvantages following the so-called "special apprentice" system, and I consider the plan under discussion has, among other things, this one advantage—that it is possible to make more and better journeymen out of the ordinary apprentice, with the possibility of producing good foremen when required, because the men so trained are coming up through the rank and file and are not differentiated from the mass by the badge or tag like the special apprentice.

While listening to the discussion my mind has been going over the various evening apprentice schools all founded with the very best of intentions, and their sponsors entitled to all possible praise because of their self-sacrificing efforts, but the weak spot of all this voluntary effort is that it is voluntary and philanthropic, and consequently lacking in discipline and business control.

Such men as Reynolds at Brainard, Schlacks at Denver, Leyn-

mark at Chicago, Reed at St. Paul, Wilkenson at Jackson, Mich., Bradley of Ann Arbor and Brooks of Dunkirk have been pioneers in this educational movement, but one after another of the schools founded by them were given up after a time, and the lack of commensurate results were entirely due to a fundamental element which is directly provided for in the New York Central scheme by the fact that the school work is done in the company's time and the young men are under control and proper discipline.

MR. G. M. BASFORD (Am. Loco. Co.): Nearly all railroads and industrial establishments have preached apprenticeship and nearly all have made serious efforts to practice it. In spite of this it would probably require from forty to seventy years for most of these establishments to recruit their service of skilled labor through apprenticeship if they relied upon present methods for the purpose. By taking the total number of skilled workmen in the employ of any large railroad and comparing with it the number of apprentices, a calculation showing the number of years required to completely recruit the number of skilled workmen through the apprenticeship system will be astonishing, and will indicate that the figures quoted above are not exaggerated.

The past generation and the present have brought a tremendous growth to all our organizations, the extent of which none of us, probably, fully realize. We have greater need than ever for trained young men ready to be trusted with responsibilities.

For many years the technical schools have done their best to supply men for leading positions and yet we are suffering for men to fill subordinate positions. Well prepared men from the ranks are what we want. The plan so clearly described by the authors of this paper will undoubtedly produce them. We need definite systematic apprenticeship, adapted to present conditions. Even if we had plenty of apprentice material, shop people are too busy to teach boys, and if the boys are put into the shop organization to learn trades, under prevailing conditions they will quickly absorb much that is harmful and more slowly learn some of the things we wish them to know. Under present methods and conditions they certainly can not be said to learn trades. This plan insures the acquisition of trades. It does more. It also insures mental development to correspond, and a certain moral training must necessarily result.

For sixty years the British Navy has profited by a plan somewhat similar to this. It is, therefore, clear that the New York Central plan does not involve navigation in uncharted waters.

The State of New York, at the Elmira Reformatory, in 1894, provided instruction in thirty-four separate trades to those who were (shall we say) fortunate enough to have an opportunity to learn them. In 1879 a School of Letters was established at the same institution as a part of an elaborate and effective educational scheme. If we had needed any precedent, here we had one years ago, and it will be to our everlasting disgrace if we permit it to be truly said that a young man, in order to learn a trade, needs to commit a crime against the laws of the people.

The New York Central has shown the way to solve the recruiting problem practically. Let us hope that all other roads and manufacturers will follow as rapidly as possible.

Mr. A. M. Waitt: It seems to me, Mr. Chairman, we have developed here a very important subject, and with such men giving time and attention to the subject as Mr. Cross, Mr. Basford and others it seems to me that after the discussion on the subject is completed we should have for the coming year an efficient committee to continue the development of this subject of apprenticeship and present a committee report that possibly will develop definite recommendations next year that could go into our Recommended Practice in place of the somewhat out-of-date recommended practice on apprenticeship that is now there. I move that a committee be appointed by the Executive Committee to consider this subject and report in continuation next year. (Motion seconded.)

The President: This motion will be put at the conclusion of the discussion.

Mr. E. W. Pratt (C. & N.-W. Ry.): I am personally very much interested in the apprentice system, and inasmuch as Mr. Cross has presented such a fine paper I would ask, in his closing remarks, if he would give us an idea as to whether this system will ultimately embrace the apprenticeship of firemen. I take it that the boiler shops and blacksmith shops, although scarcely mentioned, are included the same as the machine shop, and I will be interested to know in that respect if it is making it easier to

obtain apprentices for the boiler shop and for the blacksmith shop. Our trouble in the West seems to be that there are more applicants for apprentices for the machinist trade than for the boiler shop or blacksmith shop.

MR. R. V. WRIGHT (*American Engineer*): One important feature that has not been brought out in the discussion is the method by which the students are taught. They have no text-books at all in these schools, and the work is carefully planned to meet the needs of the students. I do not think anything like it has been used in any other school, and I believe the success of the New York Central apprenticeship system has been largely due to it. This feature should be brought out more fully before the discussion is closed.

MR. D. J. REDDING (Pitts. & L. E. R. R.): We are running one of these schools at our shop, and, noting some of the propositions raised in the paper, I want to say that the apprentices, as a general rule, fully appreciate the advantages offered them and are doing their best to profit by them. In several cases they have asked to be allowed to attend the night classes, in addition to taking the day course, in order to advance more rapidly. One way of promoting interest, not mentioned in the paper, is to make use of the more advanced boys to make shop sketches when needed. It is not advisable to start a boy too young, as in many cases where a boy of fifteen or sixteen years old is employed he only wants the job to earn wages, and to avoid going to school, and has not realized the desirability of learning a trade. For this reason we have always required the boys to serve a few months as helpers, making apprentices of those who displayed the proper interest and rejecting the others, and we have found that our best apprentices were some of those who had been compelled to work as laborers at several different callings and who realized that without a trade they could not hope to advance very far.

As to the matter of output, we do not find there is any trouble whatever. Four hours a week spent by the boy in the school is, as a general thing, made up by increased output in his work. It may not apply to the first year, when the boy is running a small lathe, or some small machine, but it does apply in the second or third year.

In regard to the effect on the men, apparently the system is having a good effect on the shop men, as we have had more of them interested in the night schools since this system has been devised.

The attitude of other roads is mentioned. I believe everybody agrees that you can not make a better investment than to spend a little money on educating the apprentices, no matter what the size of the road may be. A small road might not want to go to the expense the New York Central has undertaken, but practically the same system can be carried on with very little expense. Smaller roads can obtain the lesson papers from some outside source, and with a very little attention on the part of the officials could show good results.

Finally, it occurred to me when I got a copy of this paper that it might be of interest to know what the boys thought about it. One thing is to prescribe a course of medicine for a man, and another to know how it goes. I wrote to the boys in the second and third years and asked them to say what they thought of the apprentice course, whether it was a benefit to them or not, and if they felt they were becoming better mechanics than they would otherwise, and asked them not to sign their names to the papers, as I wanted them to say only what they wished to say, freely and frankly. One of the letters, which is quite characteristic, is as follows:

> I will hereby tell you my honest opinion about the apprenticeship system in McKees Rocks shops. The manner in which the work is carried out in the shops I can not criticize in any way, because, when taking everything into consideration, I can not think of any better way by which the work could be done and we receiving the same show as we do at the present.
>
> The drawing-school is going to make a better machinist of me than I would have been without it, because I learn there lots of things concerning the work which I would never have thought of myself. I know that I shall, when my term is up, feel more confident and more satisfied with myself than I would if I had not received the drawing-school training.

MR. ANGUS SINCLAIR: Considering the importance of this subject and the fact that it has excited more attention than anything we have had before the Association for years, I move that the discussion be suspended until the noon hour to-morrow. (Motion carried.)

THE SECRETARY: We have worked this morning on time and overtime. We have postponed the discussion of one individual paper until to-morrow, and are also to take up the discussion of this paper again to-morrow. This means that the members should get to the hall at 9:30 o'clock promptly, in order to put in a full day.

Adjourned.

THURSDAY'S SESSION.

June 13.

President Deems called the meeting to order at 9:45 A. M.

THE PRESIDENT: It was the intention to take up the first thing this morning Mr. Lovell's individual paper on Shop Cost Systems, but Mr. Emerson, who, in the absence of Mr. Lovell, has kindly consented to present it, is not in yet.

The next paper, which is "The Result of Different Valve Gears," the reports are not accessible yet. They will come a little later. So that we will have to begin with the paper on "Proper Spacing of Flues in High Pressure Boilers," and then come back to the others a little later.

We will take up, then, as the first subject this morning, the paper on the "Proper Spacing of Flues in High Pressure Boilers," Mr. C. E. Fuller, chairman. The paper is as follows:

REPORT OF COMMITTEE ON PROPER SPACING OF FLUES IN HIGH-PRESSURE BOILERS.

To the Members:

Your Committee on the Proper Spacing of Flues in High-pressure Boilers begs to submit the following report:

To be able to determine the practice on the different roads, as well as what the members would recommend, expecting to get such information that the committee could come to a conclusion and give specific information and reasons, a circular was sent out by the committee. The questions and answers, received from thirty-two members, are as follows:

Q. 1. What size bridge do you use?

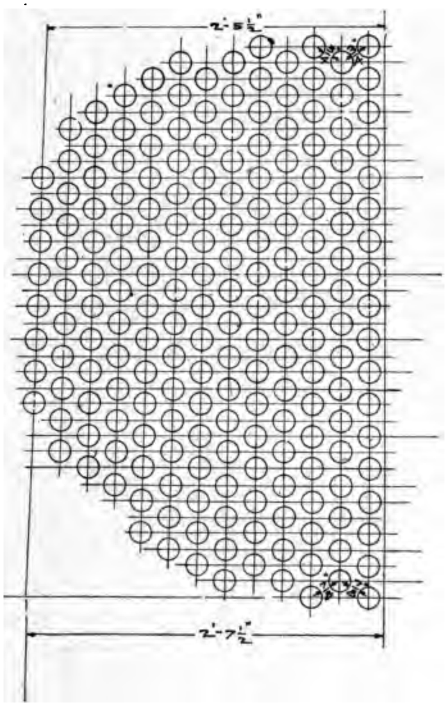
A. Over 50 per cent are using bridges 11-16 inch wide or less. Two members are using special arrangement of flues, as per cuts Nos. 1 and 2. The others are using bridges from 3/4 inch to 15-16 inch wide.

Q. 2. Is the water good or bad?

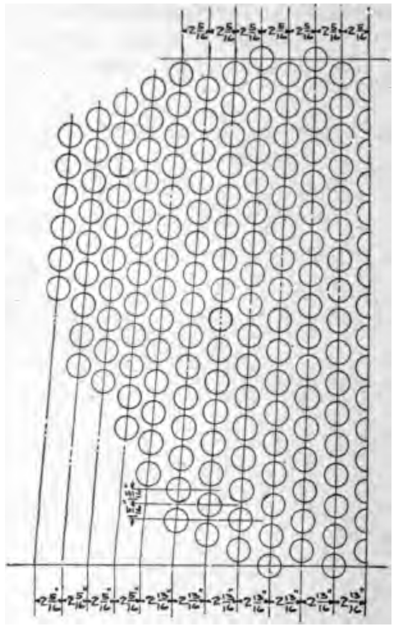
A. Nine report using bridges from 11-16 inch to 3/4 inch wide with good water. Eight report using bridges from 5/8 inch to 11-16 inch wide with bad water. The balance report all kinds of water.

Q. 3. What size bridge do you recommend for good-water district?
A. About 53 per cent recommend bridges ¾ inch wide. Two members recommend arrangement as per cuts 1 and 2.

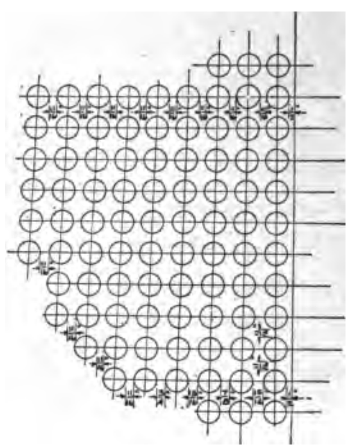
Q. 4. What size bridge do you recommend for bad-water district?
A. Sixty-two per cent recommend bridges from ⅞ inch to 1 inch wide. Three members recommend arrangement as per cuts 1, 2 and 3.



VANDALIA R. R.
Sketch No. 1.



THE MINNEAPOLIS & ST. LOUIS R. R. Co.
Sketch No. 2.



CENTRAL R. R. OF NEW JERSEY.
Sketch No. 3.

Q. 5. What efficiency have you obtained from boilers with different inds of bridges?

A. No one could give any exact data in regard to boiler efficiency.

Q. 6. Have you ascertained if there is a difference in the coal con- umption on the same class of engines with narrow and wide bridges, nd if so, what per cent of increase or decrease for boilers with wide ridges?

A. No one had any data to furnish relative to coal consumption.

Q. 7. What difference in the cost of repairs to flues on engines with ride and narrow bridges?

A. Sixty-five per cent report no data. The others claim from ten er cent to seventy-five per cent in favor of the wide bridges.

Q. 8. What is the difference in length of time in resetting flues on ngines with wide and narrow bridges?

A. Sixty-five per cent report no data to furnish. The balance say rom 60 to 90 days in favor of the wide bridges.

Q. 9. What trouble have you from leaky flues on engines with nar- ow bridges?

A. Over fifty per cent report more trouble with narrow than wide ridges.

Q. 10. What trouble have you from leaky flues on engines with wide ridges?

A. Over fifty per cent report less trouble with wide than narrow ridges.

Q. 11. What arrangement of flues do you recommend? If different rom the common arrangement now used, please send blue-print.

A. Over fifty per cent recommend the common arrangement of flues. Three recommend special arrangement, per cuts 1, 2 and 3. Two think he arrangement of flues is immaterial.

Q. 12. What is your custom in beading tubes in fire box, and what o you allow for bead?

A. Sixty per cent prosser, roll and bead. Fifty-five per cent allow -16 inch for bead.

Q. 13. What is your method of treating tube ends in front tube heet?

A. Over thirty-five per cent report tubes rolled and expanded. The alance are beading the tubes from five per cent to twenty-five per cent.

Judging from the answers received, your committee would say that he majority of the members are in favor of wider bridges than are used t the present time, but no one seems to have made any tests regarding he water circulation between flues or the consumption of fuel, so it is

impossible to get data bearing upon these important points. The data furnished by a few parties was really nothing more than off-handed information; no exact figures were given on which the committee could base an opinion. One of the members recommends very strongly a special arrangement, as shown on cut No. 2, an arrangement which they have used successfully for a number of years, but no special tests have been made to determine the efficiency as compared with boilers having the common arrangement of flues; although they are positive it is a great improvement over the present arrangement in general use. To determine the proper spacing of flues, this subject must be considered from the transportation as well as the mechanical standpoint; that is, the engine failures on account of leaky flues, as well as the cost of maintenance and steaming qualities of an engine, must be considered. The committee is of a uniform opinion that wider bridges, from ⅞ inch to 1 inch, or even wider, should be recommended, but before determining exactly what size bridges should be used they consider it advisable that a series of tests be made to determine the water circulation between flues, the coal consumption for boilers with different size bridges, as well as the cost of maintenance in regard to flues.

The committee started several tests to determine the above question in regard to water circulation between flues and the coal consumption, and to ascertain if the same size bridges could be used in both large and small boilers without interfering with the steaming qualities of the engine, but they were unable to continue the tests so that positive data could be obtained on account of unavoidable interference of business.

From the committee's investigation we feel that the width of bridges and the necessary reduction in flue heating surface can be determined only by a series of tests to ascertain how far we can go without detriment to the efficiency of the boiler, both in regard to steaming qualities and coal consumption, and at the same time obtain the best results in flue maintenance.

C. E. Fuller, Chairman,
H. J. Small,
T. J. Cole,
John Tonge,
O. H. Reynolds,
Committee.

Bloomington, Ill., May 7, 1907.

Mr. Fuller: Since this report was made up, Mr. Tonge, one of the members of the committee, has gotten together some data, and, as I think it would be of interest to the convention, I would like to have him give that at this time.

Mr. John Tonge (Minn. & St. Louis R. R.): Mr. President, for the benefit of the Association and for its consideration I

have prepared this drawing, Fig. A. Will say in the first place that the Association design has not been disturbed; it is the same as was adopted by the Association years ago. The flue arrangement here shown represents a number of engines, as you will find on the first page of the pamphlet, built since 1892; it also represents the condition of the old engines as they have been changed since that time.

On the next page you will find a statement showing the number of flues in the old engines and the new, also the number of flues displaced, as considered in each group.

In column H you will find the total number of flues displaced, and the amount of material saved is shown by classes in column J. You will also find the number of flues displaced amounts in value to $3,908.94. In the old engines the total number of flues displaced would make 10 63-100 sets complete for a Mogul engine having 316 flues per set, which is the number of flues in our engines, and the same represents a saving of $7,118.78 for material only.

In column I the engine is figured as having flues removed and worked over once every eighteen months for a standard engine and once every two and one-half years for Mogul engines. We do not find it necessary to remove flues in Mogul engines only once in two and one-half years; they go through the shop twice in that time.

In column J the labor only is considered for removing flues and applying, welding tips and swedging and cleaning flues, which, on a Standard engine of 147 flues, amounts to $36.29, and on a Mogul engine of 316 flues amounts to $73.29.

You have on the next page the cost of labor and material in an engine of this type having 316 flues, and one having 378 flues. The material for 316 flues is $623.57 as against $745.92 for 378 flues, a difference of $122.35. Considering fifty engines of this same class and the saving of material, it would amount to $6,464.50.

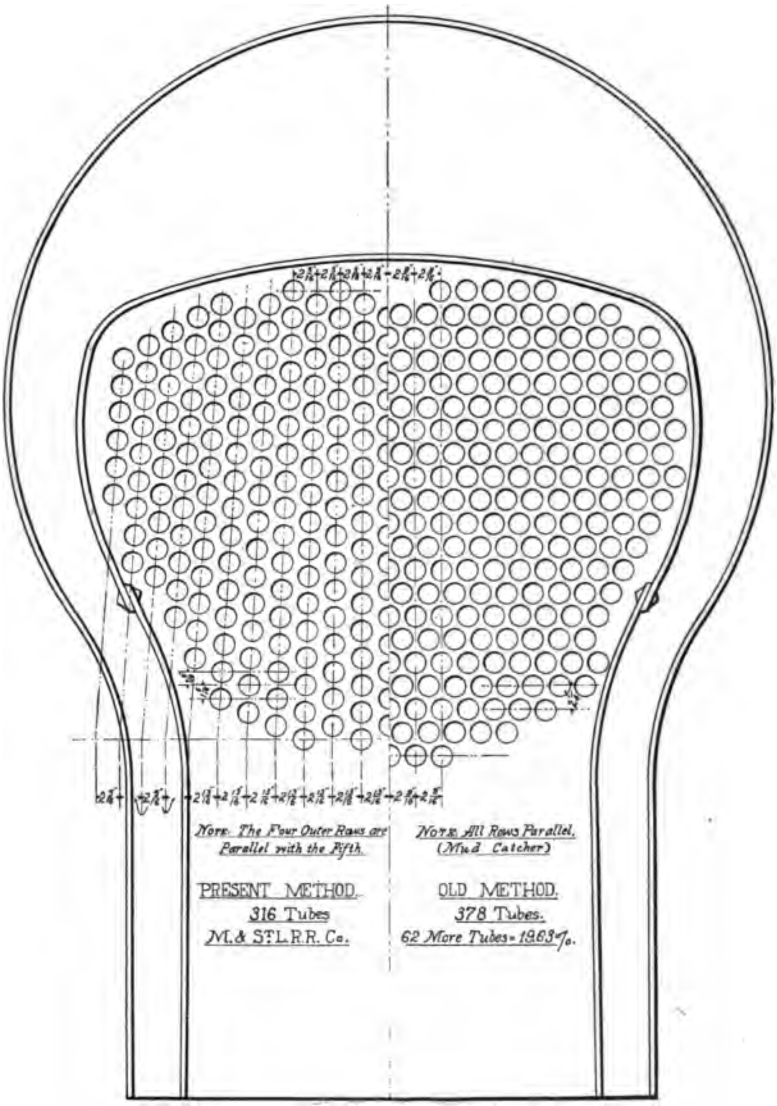
In the footnotes below you find the expense for installing a set of flues of 316 in number and of 378 in number. I wish to call your special attention to the Standard engine, a number of which we have. Originally they had 188 flues; they

were reduced to 137 flues and I would ask that you particularly note the money value saved as stated in column J. It is not necessary to speak of the advantage gained in many ways by flue displacement, for the reason that advantages gained are very plain and which any practical man readily understands, but you will notice, in the first place, the increased distance from the upper flange to the top row of flues, which is about 2½ inches, and also from the corners and the sides. The additional strength given to support the upper flange and in the upper corners practically eliminates oblong holes existing in a boiler having flues as shown in sketch containing 188 tubes.

On the next page is shown the expanders which we use and on the last page is shown the method of laying out the tube sheets and the manner of working same, and close adherence to the method referred to in working the flue sheets will be found very beneficial.

In this drawing we have the same boiler as shown in the previous drawings. You will notice that one-half is shown with flues spaced in the new design, the other half is shown in the old design. You will note I term the old design the " Mud Catcher," as it is very plain to me how easily the mud accumulates on the old design as here shown, whereas the new design of spacing permits the rapid settlement of sediment and a better opportunity for boiler-washing.

The money consideration of material as presented with this pamphlet is quite an item, especially so when you go into the consideration of the same on extensive systems. True enough the Minneapolis & St. Louis is a small road, but it has been proven, by the design of flue spacing as here shown, that our engines are easily kept clean, that the steaming qualities have not been reduced, but to the contrary much better steaming engines have been the rule. The leaky flues have been practically eliminated, all owing to the method of spacing flues which has been followed on the M. & St. L. road since 1892.


Note: The Four Outer Rows are Parallel with the Fifth.
Note: All Rows Parallel. (Mud Catcher)
PRESENT METHOD.
316 Tubes
M. & ST. L. R.R. Co.
OLD METHOD.
378 Tubes.
62 More Tubes = 19.63%.

The statement is as follows:

As the result of many years of practice, the following data have been compiled to show the net results gained, financially and otherwise, by the introduction of present flue spacing as herein shown, which will be readily understood by the members of the Association. With the data given it is unnecessary to enter into any lengthy remarks.

[illegible] BUILT FOR THE MINNEAPOLIS & ST. LOUIS R. R. CO. WITH NEW FLUE ARRANGEMENT.

OFFICE OF MASTER MECHANIC, JUNE, 1907.

[illegible]	[illegible]	[illegible]	Built	Length of Service	No. of Flues	Length of Flues	Pressure in Pounds
[illegible]	[illegible]	Boiler built by Brook	1898	9 Yr.	190	11′-2″	180
[illegible]	[illegible]	Baldwin	1898	9 Yr.	220	11′-0″	200
[illegible]	[illegible]	Baldwin	1899	8 Yr. 6 Mo.	220	11′-0″	200
[illegible]	[illegible]	Baldwin	1906	1 Yr.	220	11′-0″	200
[illegible]	2	Rhode Island	1892	15 Yr.	225	10′-10″	180
Mogul	15	Schnectdy	1899	7 Yr. 9 Mo.	316	12′-3″	200
Mogul	8	Schnectdy	1906	10 Mo.	316	12′-3″	200
10 Wheel Passeng'r	4	Schnectdy	1900	6 Yr. 3 Mo.	274	14′-8″	200
8 Wheel Standard	2	Schnectdy	1906	10 Mo.	296	12′-0″	200

STATEMENT SHOWING THE DISPLACEMENT OF FLUES ON M. & ST. L. ENGINES BY NEW FUEL ARRANGEMENT.

JUNE, 1907.

A	B.	C.	D	E.	F.	G.	H.	I.	J.
Engine Nos.	Year Built	Class.	No. of Flues Old Style	No. of Flues New Style	No. of Flues Dis-plac'd	No. of Engs. in Each Gr'up	Total No. of Flues Dis-plac'd	No. of Times Flues Re-tipped	Amount Saved Since 1892
3 to 12	1877	16″x 24″ Std. Baldwin	142	132	10	10	100	10	$246.77
19 to 31	1880	17″x 24″ Std. Baldwin	154	147	7	13	91	10	224.64
35 to 39	1881	17″x 24″ Std. Pittsburg	243	190	53	5	265	10	654.31
45 to 49	1881	17″x 24″ Std. Manchester	188	147	41	5	205	10	505.88
55 & 68	1892	18″x 24″ Std. R. Island	240	225	15	2	30	10	69.63
60 to 67 69 to 72	1882	17″x 24″ Std. Manchester	188	147	41	12	492	10	1214.63
73 to 78	1898	19″x 24″ Sw. Baldwin	264	220	44	6	264	4	244.79
81 to 95	1899	20″x 26″ Mogul	378	316	62	15	930	3	647.88
125 to 128	1901	19″x 26″ 10 Wheel Pass.	328	274	54	4	216	2	100.41
115 & 116	1906	19½″x 26″ Pass. Standard	354	296	58	2	116		
80 & 96 to 102	1906	20″x 26″ Mogul	378	316	62	8	496		
50 & 79	1906	19″x 24″ Sw. Baldwin	264	220	44	2	88		
TOTAL							3293		$3908.94

This total number of flues displaced would make 10.63 complete set of flues for a Mogul engine which applied would amount to $7,018.78.

NOTE.— In column "I" an engine is figured as having flues removed and worked over once every eighteen months for a Standard engine and once every two years and one-half for a Mogul or ten-wheel passenger engine.

In column "J" the labor only is considered for removing flues and applying, welding tips and swedging, and cleaning flues which on a Standard engine of 147 flues amounts to $36.29 and on a Mogul engine of 316 flues amounts to $73.29.

Cost of labor and material for removing old flues and installing one new set complete (316) new style, as compared with removing and installing one set complete (378) old style.

	316 Flues New Style	378 Flues Old Style	Difference in Cost
Cost of Flues—Material............	$623.57	$745.92	$122.35
Cost of Ferrules—Material	8.60	10.28	1.68
Labor installing Flues	22.23	26.32	4.09
Labor removing old Flues.........	5.88	7.05	1.17
Cost, Labor and Material for 1 Eng.	$660.28	$789.57	$129.29
Cost, Labor and Material for 50 Engs.	$33014.00	$39478.50	$6464.50

FOOTNOTE:

1. Labor for installing one set of new flues (316) new style, was figured 38 hours actual time for one boilermaker at 38 cents per hour and one boilermaker helper at 20½ cents per hour.

2. Labor for installing one set of new flues (378) old style, was figured 45 hours for one boilermaker and one helper at same rate, this time being based on the same ratio per flue as in footnote No. 1.

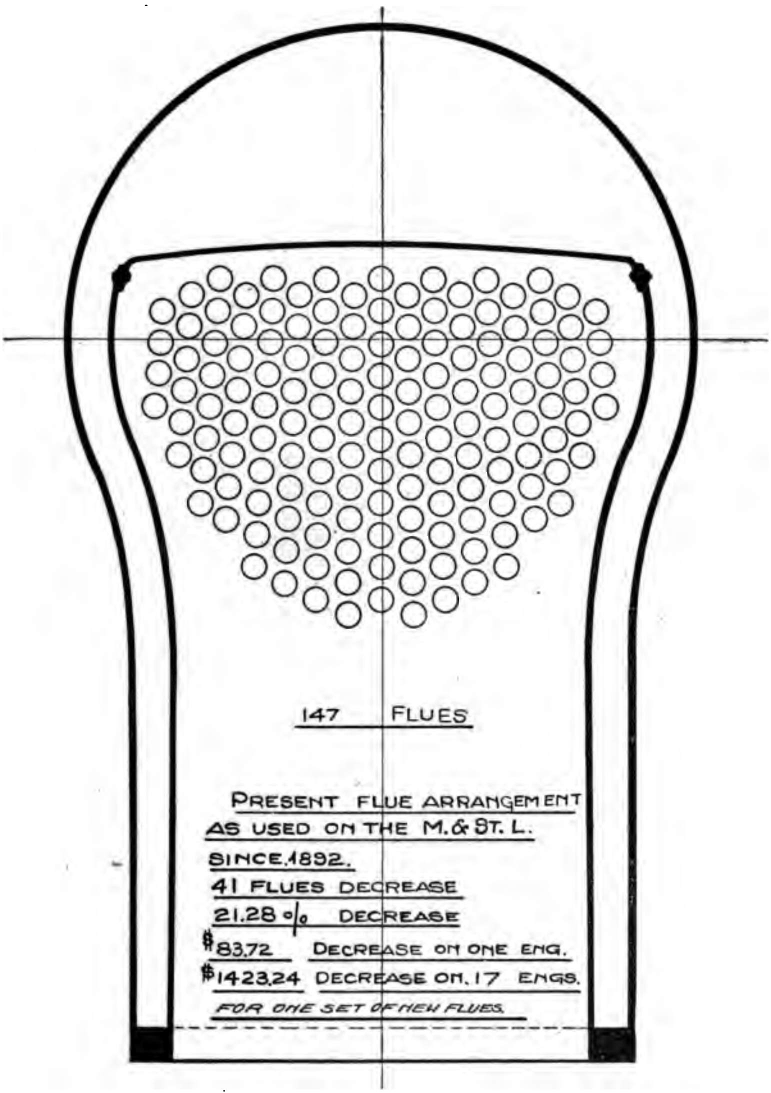
3. Labor for removing one set of flues (316) new style, was figured 9 hours actual time for boilermaker and 12 hours for boilermaker helper at 38 cents and 20½ cents per hour respectively.

4. Labor for removing one set of flues (378) old style, was figured 11 hours for boilermaker and 14 hours for boilermaker helper, this being same ratio per flue as in footnote No. 3.

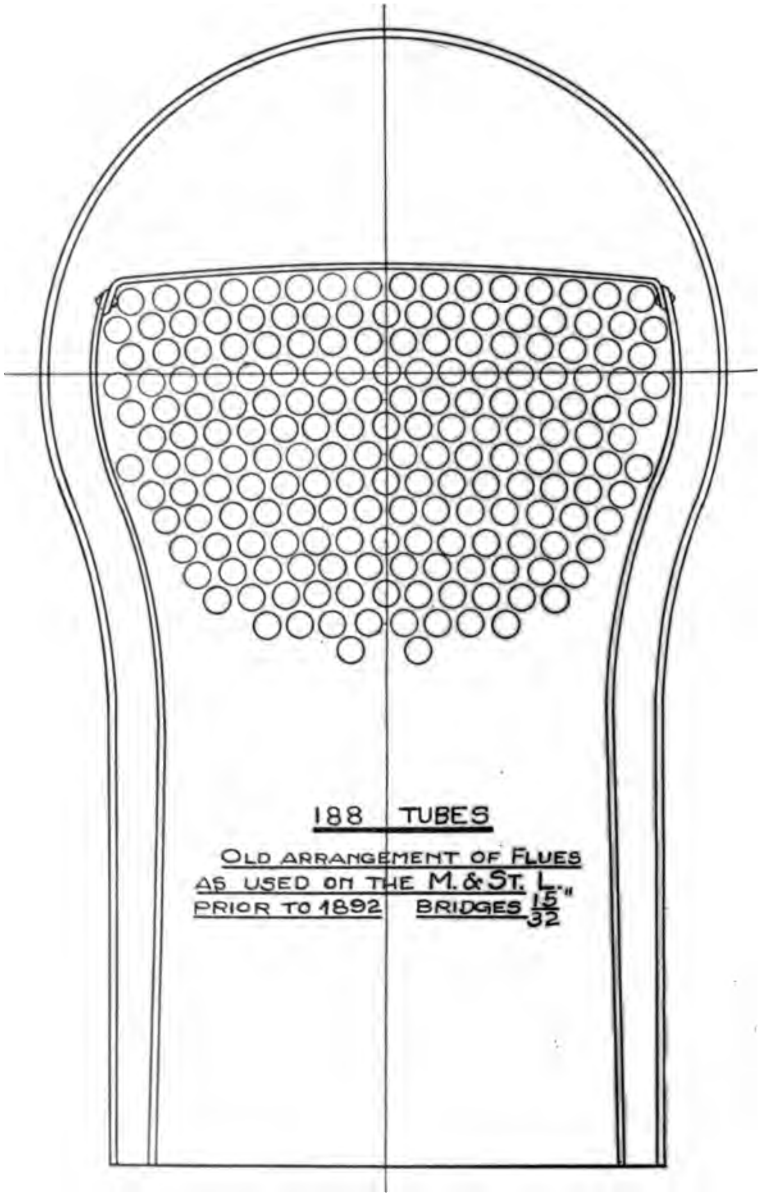
In working tubes we always roll the tubes first, sectioning afterwards with the Prosser Expander, starting at either of the sections marked (1) on the blue-print. Roll all the tubes in these sections, proceeding to section marked (2) and finishing with section marked (3). Then use the Prosser expander, taking the different sections marked 1, 2 and 3 in the order named.

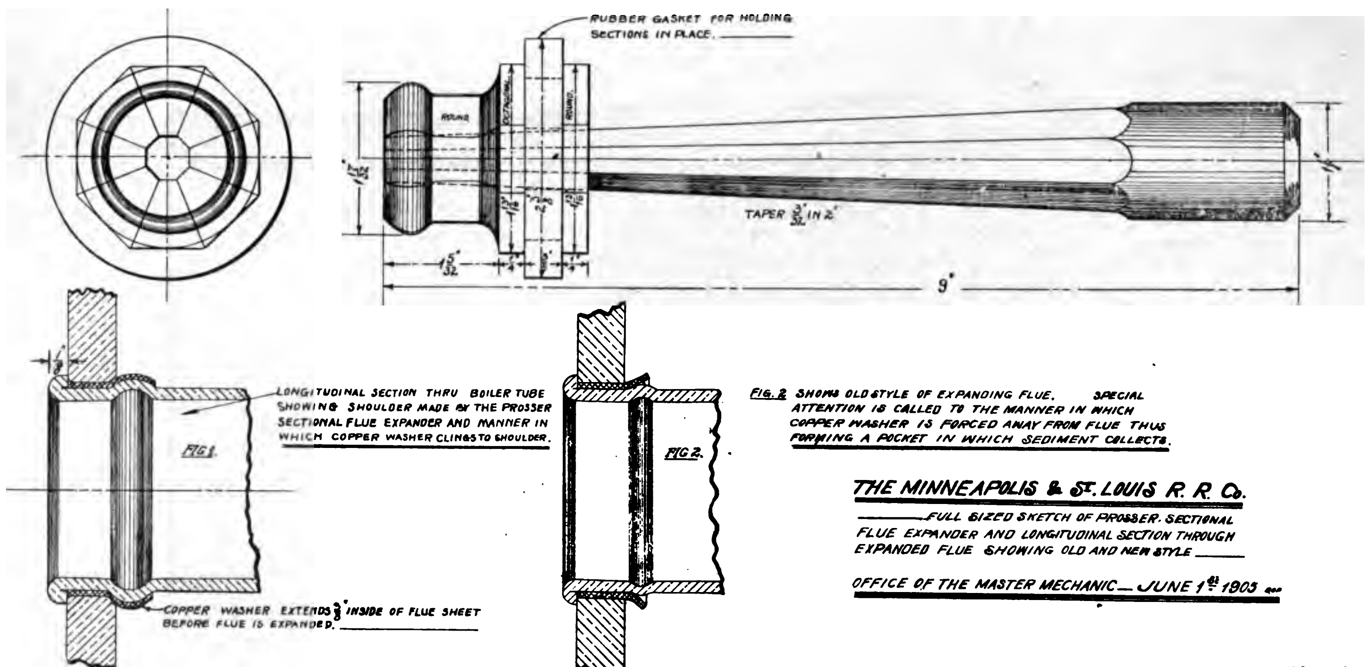
We leave two inches of metal between the tube holes in flue sheet and the flange of flue sheet. By so doing, it very much strengthens the flange of flue sheet, which also adds much greater support to crown sheet, for the reason that the flue sheet is not weakened by flue holes being too near the upper flange.

Many writers have given their experience of flue sheets moving upwards from the manner in which the flues are worked. In some instances I have noted they report ¾ inch out. It is not by any fault of the rollers or Prosser expander where the raising of the flue sheet has occurred, but rather from the method in which the work was done. We have trammed out sheets before and after rolling and sectioning, from the center of bottom to center of top and from center of bottom to extreme corners, and the difference shown by trams was scarcely noticeable.



147 FLUES
PRESENT FLUE ARRANGEMENT
AS USED ON THE M.& ST. L.
SINCE 1892.
41 FLUES DECREASE
21.28 o/o DECREASE
$83.72 DECREASE ON ONE ENG.
$1423.24 DECREASE ON 17 ENGS.
FOR ONE SET OF NEW FLUES.


188 TUBES
OLD ARRANGEMENT OF FLUES
AS USED ON THE M. & ST. L.
PRIOR TO 1892 BRIDGES 15/32"


RUBBER GASKET FOR HOLDING SECTIONS IN PLACE.
ROUND
OCTAGONAL
TAPER 3/32" IN 2"
9"
1 5/32"
FIG 1.
FIG 2.
LONGITUDINAL SECTION THRU BOILER TUBE SHOWING SHOULDER MADE BY THE PROSSER SECTIONAL FLUE EXPANDER AND MANNER IN WHICH COPPER WASHER CLINGS TO SHOULDER.
COPPER WASHER EXTENDS 3/8" INSIDE OF FLUE SHEET BEFORE FLUE IS EXPANDED.
FIG. 2 SHOWS OLD STYLE OF EXPANDING FLUE. SPECIAL ATTENTION IS CALLED TO THE MANNER IN WHICH COPPER WASHER IS FORCED AWAY FROM FLUE THUS FORMING A POCKET IN WHICH SEDIMENT COLLECTS.
THE MINNEAPOLIS & ST. LOUIS R. R. Co.
FULL SIZED SKETCH OF PROSSER. SECTIONAL FLUE EXPANDER AND LONGITUDINAL SECTION THROUGH EXPANDED FLUE SHOWING OLD AND NEW STYLE
OFFICE OF THE MASTER MECHANIC — JUNE 1st 1905

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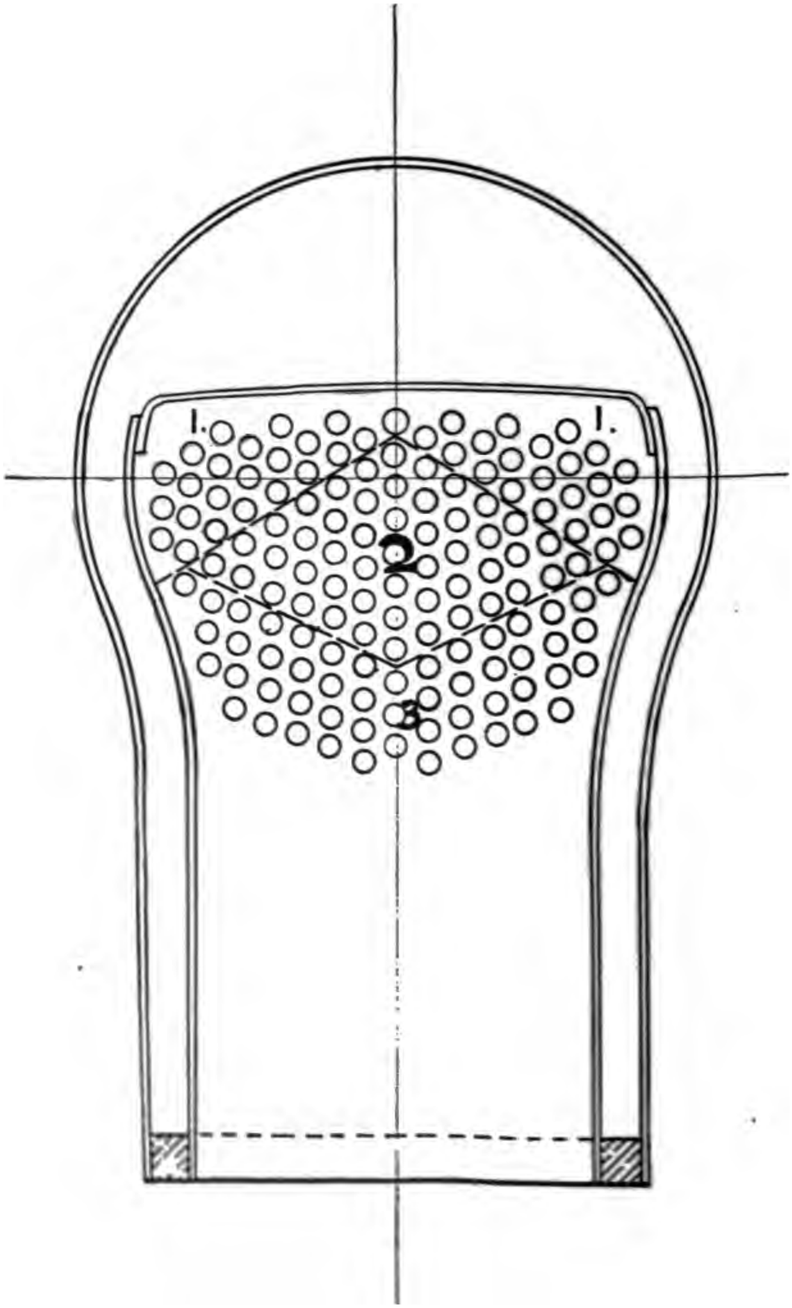

1.
1.
2
3

MR. M. E. WELLS (W. & L. E. Ry.): I do not know that I an add anything more to the discussion than has already been aid. It has been demonstrated by a great many roads that you an reduce the heating surface of the flues and get a better water irculation and still maintain the same steam generation. There s no question about it, and there is no question about the advanages of doing this which the gentleman points out, getting the lue spaces further apart and making less space for the accumulaion of incrusting matter. I do not see very much more that can e said on the subject. What the gentleman presents is good, in ny opinion, as applying to old boilers.

MR. C. A. SELEY (C. R. I. & P.): I would ask Mr. Tonge vhat is the bridge space in the engine?

MR. TONGE: The bridge space is 1 3-16 inches at the bottom.

MR. F. F. GAINES (Cent. of Ga. Ry.): At some previous neeting of the Association some of the members called attention o increasing the bridge spacing by means of using a very much lecreased end on a standard flue to accomplish practically the ame object of the greater spacing of the flues; that is, to get larger area around the flue at the bridge sheet. It seems to me his is the principal thing to be gained in the larger spacing of he flues, to get more room around the bridge.

Another thing in connection with the flue matter that has not een touched on as strongly as it might be is the method of andling the flues, applying them and afterward maintaining hem. I find if you try the experiment of putting a flue into a iece of metal and constantly rolling it, that you will roll it so nuch that the bead has left the sheet entirely, and I find many ases where there have been a lot of flue troubles that have been lue to rolling; and if you cut out rolling and prosser entirely, it will materially cut down your flue troubles.

MR. G. W. WEST (N. Y. O. & W. Ry.): We have been folowing the practice specified by Mr. Gaines for a number of years, utting 1¾-inch safe ends on 2-inch flues and 2-inch safe ends n 2¼-inch flues, and we have materially reduced our flue roubles and get better steaming engines, and our flue sheets have lmost doubled their life.

THE PRESIDENT: Is there anyone else who would like to say something on this subject?

MR. WM. FORSYTH (*The Railway Age*): The facts brought out by Mr. Tonge have been known for a number of years. I remember that three or four years ago there was quite an epidemic of wide flue spacing and the advantages which he points out were then understood. It is strange to me that, in view of that fact, that probably nine-tenths of the new locomotives that are being built now have the same small bridge spaces they formerly had. I noticed that on the drawings which come from the locomotive works, and I wish some one would explain why that is. One reason which I would suggest is that, although the opinion has been expressed there is no material difference in the evaporation, if you reduce the tube heating surface 20 or 30 per cent. What has been offered has been only opinions on this subject, and what the Association needs is some actual demonstration by a carefully measured test, and I hope that if this committee is continued or this work is continued that something of that kind will be taken up and also that the committee be authorized to expend some money in constructing a test boiler to find out some of these things about the locomotive tubes, so that they will be enabled to get at actual facts which will be more convincing than the opinions which we have had heretofore.

MR. F. H. CLARK (C. B. & Q. R. R.): I think this question of flue spacing should be considered in connection with several other matters; the water, perhaps, the steaming qualities of the boiler, and circulation generally. I remember a number of years ago we changed an engine which previously had 5/8-inch bridges, and we increased the bridges — I do not remember whether we did it by putting in a new flue sheet and a number of smaller tubes, or used the same size tubes and a lesser number. At any rate, the result was to make a very poor steaming engine of an engine that was not a good steamer in the first place. We got below the necessary heating surface for that particular engine. Since that time we have increased the width of our bridges somewhat, probably 1-16th of an inch, and we find that spacing to be pretty satisfactory for almost any size of boiler, provided we have a good circulation outside of the flues between the flues and the

shell. It does not seem to matter much what the spacing is as long as you get good circulation.

MR. WM. MCINTOSH (C. R. R. of N. J.): I think I can answer Mr. Forsyth's inquiry as to why advantage is not taken of the apparently well understood features in favor of the wider bridge. There is a natural desire to obtain as much heating surface as possible in a boiler, the spacing being necessarily limited. I have had experience with the system of spacing that Mr. Tonge described, particularly in the West, where the water is especially bad, and we found there was great advantage in dispensing with a few flues and taking the additional space for circulation. Possibly the same result could be obtained by following Mr. West's idea of reducing the end of the flue, and if it could it would be the best plan to follow, though the restriction of the opening at the end of the flue might in some respects interfere with the heating results in other directions.

MR. H. H. VAUGHAN (Can. Pac. Ry.): This question of flue spacing appears to me to be to a large extent a matter of conditions. We have, for instance, certain districts in which the water is exceedingly good — in those districts there is no question but what an engine having a 5/8 or 11-16-inch bridge can be run with perfect satisfaction. In the State of Maine, with particularly pure water, the engines run almost indefinitely with very little flue trouble. It also seems to me, from what we have heard in the last few years and this committee's report, there is no doubt that a bridge of 13-16 or 7/8, or even larger, has proved advantageous in bad-water districts. I think there is no doubt that flue difficulties have been greatly decreased by going to wider bridges than 3/4 of an inch in bad-water districts. It seems to me, however, sometimes we make a mistake in bad-water districts by heavy prossering after increasing our bridge. That will certainly allow the scale to accumulate around the bead formed on the inside of the bridge and almost neutralizes the effect of the larger bridges. We have obtained good results in bad-water districts by doing away with the prossering altogether, so as to leave as clear a chance as possible for the water to circulate and to prevent scale from accumulating as much as possible.

Mr. Tonge's argument seems to be based very largely on the

saving in the cost of renewing flues. I do not think I would agree with Mr. Tonge in assuming that it would be a good thing to have a smaller number of flues because it costs less to safe-end them. It seems to me that it is fairly safe to assume that the larger the number of flues you can get into a boiler without affecting the circulation and without getting them placed so close to the flanges that we have no room there for flexibility the better. I think the general principle in designing an engine is to take a certain weight of engine and try to design it to get in as much heating surface as possible, and I believe that is the right principle on which to design a boiler. If we are going to reduce our heating surface five to ten per cent, we may not by any test be able to distinguish any difference in the economy of the engine, but I really feel there is one thing we can be certain of and that is that the decreased economy is there. You can not cut down the heating surface ten per cent on an engine and expect to evaporate as much water right along as you would do with a larger amount of heating surface, and the loss in evaporation will certainly more than counterbalance the cost of replacing flues; in other words, I believe that until we get so many flues that we are getting more than the boiler can take care of comfortably, it is a good thing to have them. I would not cut out flues to save the cost of safe-ending them.

In regard to making further tests to determine to what extent the flues can be reduced, it seems to me that we would be spending money on a series of experiments that would give us very little result. Those of you who have followed the results at St. Louis based on engines having quite widely varying amounts of heating surface can appreciate the difficulty that is going to be encountered in taking up engines varying five per cent in heating surface and getting any figures which will give results that will be of much value. That is about what we would come to. Take one engine with rather more flues and another with rather less and, as a matter of fact, we would simply have two engines with a slightly varying amount of flue heating surface, and it seems to me very improbable with five per cent of flue heating surface variation we would not expect over one or one and a half per cent difference in evaporation, and that is an amount that could

hardly be detected except by most extensive tests. Individual tests will vary that amount among themselves. The point seems to me to stand largely between 7/8 bridges, smaller bridges, and those combination arrangements with 7/8 or 1-inch bridge at the bottom, with a smaller bridge at the top. That arrangement is peculiar and it seems to me it may have a good deal of value. We do actually have more trouble with the lower flues than we do with the upper ones, and if we can use a compromise arrangement, and in that way get in rather more flues, why, so much the better; but personally I rather prefer our arrangement in which we use a straight 7/8-inch bridge at the back and 3/4-inch bridge in the front tube sheet. There is no need to carry the same arrangement of spacing in the front sheet that you do in the back — there is plenty of room there for circulation, and we can get the same weight of boiler by bringing the flues down in the front that you can by spacing closer at the back. I should doubt if there is a saving of over two or three tubes by the special arrangement shown.

Mr. M. E. Wells: I think Mr. Forsyth's criticism that nothing has been done in connection with this flue question, along the lines of increased bridges, is not quite just, because a great many boilers, in fact most of the boilers which have been manufactured in recent years, have increased bridges. I know of a great many. Mr. Vaughan spoke of some having 7/8-inch bridges, and I know of many that have as high as 1-inch bridges.

I think the idea of a little wider bridge on the bottom, and a little narrower bridge at the top, where there is less trouble, is perhaps a good proposition.

Concerning the cut which Mr. Tonge presented to you, I do not understand he advocated reducing the heating surface as a means of helping this matter; it is only a suggestion in connection with old boilers, and I am sure that the gentleman is entirely right, because I have seen a great many experiments of the same kind myself, where the heating surface has been reduced and verv good results secured, and still not destroy the steaming properties of the boiler. It is a difficult problem to work out, and it is a thing that should be pretty carefully figured on before you make

a change, to be sure you do not destroy the steaming properties of the boiler; but to a reasonable limit, I think, on old boilers, that the idea is all right.

Mr. George Wagstaff (N. Y. C. Lines): I think Mr. Vaughan struck the keynote when he said that conditions govern more than anything else the question of flue spacing. Those of us who have had to do with a number of different roads know that what is good practice in one district is not in another, and I think this flue question must be dealt with locally if we expect to get the best results. I also believe it is impossible for us to make any standard that would be appropriate for all roads. I do not believe we could get any spacing that would be satisfactory for all roads.

After the experience I have had with flues I have made up my mind that the flue problem resolves itself into two things — those of good material and good care. Flues are like most other things in life — the better care you take of them the better results you obtain. We have found in our experience recently that the trouble from flues comes more from their being filled up, or plugged up from the fire box, rather than the troubles that come from the inside of the boiler or the spacing of the tubes.

Mr. Tonge: This is what I term the "mud catcher," for the reason that we do not find it necessary to remove the flue from this layout only once in two years and a half, and you can not run that with this other layout for two years and a half with the same waters, as you will see here how easily the mud will drop from flue to flue and fill up the bottom of the boiler, and at the same time you do not have the opportunity for washing them.

The money consideration of material is quite an item when you go into a large number of engines. True enough, this is on a small road, but the design shown here has been followed since 1892. Better steam engines can not be found than are on the Minneapolis & St. Louis road to-day. Consequently, you have good steaming engines and are reducing the amount of flues as shown in the statement, and the money value must be considered, for the reason that it shows permanently, and when you have the steam to haul the train, gentlemen, you have all you want.

Mr. G. W. Wildin (L. V. R. R.): Mr. President, I do not quite agree with Mr. Vaughan and Mr. Wagstaff that this ques-

tion of flues is a local one. Certainly, conditions that will give good results in bad water will give good results in good water. I think we should make an effort to determine what is good practice for bad water. Then we will unquestionably have good engines for good water. The practice of railroads to-day of shifting engines from one division to another bars the local treatment as to the spacing of flues entirely.

Mr. Vaughan: Mr. President, I did not mean to be understood that we should build engines for good-water districts with small bridges and for bad-water districts with wide, but I do mean that in a good-water district the small bridge will give you perfect satisfaction. You have not in such a district gained anything by going to the wider bridge, and it is shown that the wide bridge is not necessary in a good-water district.

Mr. Wm. Forsyth (*The Railway Age*): Mr. President, I think the great difficulty about getting at the truth of this question is that we can not do it with a normal boiler. The only way we can obtain the information desired is by the use of an experimental boiler. I do not believe it will ever be settled by tests or work with the regular locomotive in service, and the committee admit here that they were unable to get positive data on account of unavoidable interference with business. They also recommend that a series of tests be made "to ascertain how far we can go without detriment to the efficiency of the boiler," in the matter of spacing the tubes. In view of these statements in the report of the committee, and of the difficulty of settling the question with the ordinary boiler, I move that a committee be appointed to ascertain the most economical spacing of tubes in locomotive boilers, and the relative value of the heating surface of tubes of different lengths; that the committee arrange to have experiments made at Purdue University; that a fund be provided for the expense of a special experimental boiler for the purpose. (Motion seconded by Mr. Walsh.)

Mr. Vaughan: Mr. President, before that motion is put — I do not want to disagree with Mr. Forsyth — but it seems to me that it should be left to the Executive Committee to decide whether those tests were carried out or not, because it means the spending of a very large amount of money, and I do not think

any good case has been made out for leading us to expect that we would get any results at all from such a series of experiments. I can see nothing in that series of experiments but a test, on two boilers, with varying amounts of flue surface, and otherwise identical, and it does not seem to me that such a test would be worth the amount of money that we would be called upon to expend. There are other subjects of perhaps greater importance. This might be worked in incidentally, but to pass a resolution empowering us to spend money just to test the relative evaporation of two boilers with varying numbers of flues seems to me to be going into the testing business rather too quickly. That series of tests would cost $4,000 or $5,000, and I do not think we would get any results from it. I think, instead of that proposition, if the convention thinks it advisable, it would be better to appoint a committee to outline what tests they would suggest, and not go into testing without knowing exactly what was going to be done.

MR. WILLIAM McINTOSH, S. M. P. (C. R. R. N. J.): Mr. President, I quite agree with Mr. Vaughan that it would not be advisable to give directions to proceed with a test of that kind. It might, however, be well to have the Executive Committee consider it further.

THE PRESIDENT: I believe, under the rules, the Executive Committee would have to consider the matter, anyway.

MR. McINTOSH: At any rate, I do not think the tests at Purdue would give us much information. If this problem were to be worked out, it had better be done in a practical way by some road that has the conditions, and most of them have, of such variations, and let them build boilers of different types, and keep a very close record of their work. I think more could be determined in that way than by a test at the university. As has been said, it is largely a matter of conditions. In a good-water district, you can get along successfully with a fairly narrow spacing. If you are in a bad district, you can save money by a wider spacing and the better circulation that will follow. In the West, for instance, there is no question in my mind about the advisability of the wider spacing. In the eastern districts, where the water is better, we have not found it necessary to follow the wide spacing to the same extent, although I am seriously considering now

the advisability of doing so, and for this reason: With the large boilers that we are operating to-day, high steam pressure and the strenuous service to which they are subjected, we find that the results we obtained previously, with lighter loads, lower steam pressure, can not now be secured under the changed conditions, and that there is a possibility, and I believe a strong probability, of our being able to economize by sacrificing some theoretical heating surface and securing the practical advantages of better water circulation.

THE PRESIDENT: Mr. Forsyth, I think, under the former ruling, that this matter would really have to be handled by the Executive Committee. You have no objection to incorporating that in your motion?

MR. FORSYTH: No, Mr. President. I will modify the motion to that extent.

MR. J. H. SETCHEL: Mr. President, it seems to me that if members will look at the arrangement of flues as presented by Mr. Tonge, they will not only recognize the fact that many of the evils which we have been subjected to heretofore are cured by the spacing which he offers, and which is in accordance with the practice recommended by this Association for many years, in this, that it gives a better spacing around the flange of the tube sheet, where great difficulty has been experienced by the crippling of the sheet, both on the sides and next to the crown sheet, and in the spacing of the tubes one above the other. That has been the Recommended Practice of this Association for years, and I was not aware that anything else was being done. I do not believe that anything else should be done, because it obviates the lodgment of sediment, gives a better circulation and in many ways is a good thing to do.

It has been mentioned that increasing the spacing allows of the tubing being swedged down. That, it seems to me, is not good practice, in this, that while it does increase the space in the tube sheets, it does not increase the water circulation, and it leaves a shoulder just inside of the tube sheet for the deposit of scale, and really increases the trouble that all have in keeping the flues tight; and unless that is filled up by a copper thimble so as to make a level surface and prevent a corner for the deposit

of scale, we shall increase our difficulty rather than cure it. This practice, as suggested by Mr. Tonge, deserves better consideration than it is receiving, and surely ought to be generally adopted by this Association.

THE PRESIDENT: You have heard the motion of Mr. Forsyth, which he has modified so as to put the matter in the hands of the Executive Committee.

(The President put the question on the adoption of the motion, and it was lost.)

MR. F. F. GAINES (C. of Ga. Ry.): In line with the discussion of this subject, it seems to me that, having the limited amount of money with which to make tests that this Association has, it would be quite proper and fitting if there were a standing committee to outline certain important and valuable tests, and then submit a report to the members of the Association, to pick out which would be the most important and as to which we would most desire to have tests made. If we have only a limited amount of money, I think the subjects that are most important to the members of the whole Association should be the ones taken up.

MR. R. D. SMITH: Mr. President, I move that the report of the committee be received, and that the committee be discharged.

MR. J. F. WALSH (C. & O. Ry.): Mr. President, I think this is too important a subject for us to pass over so lightly. This subject of flue spacing is certainly an important one, and it is more or less, so far as the crowding of a great many flues into our boilers is concerned, quite a modern one. In my memory easily enough, we jumped with a 17 by 22 engine and a 48-inch shell, from 125 flues to 165 flues. With the 125 flues and all the steam that the engine would need, we would run those engines from twenty to twenty-four months, without taking the flues out. Changing the flue sheets and putting in 165 flues, with the same type of engines and with, of course, all the steam we needed, perhaps more than we needed, we would have to change the flues in six months. Now, then, we are running engines to-day with which, if we get six or eight months' service, after thoroughly overhauling those engines and putting in new flues or flue ends, we are doing very well. If anybody is going to speak authoritatively upon the matter of changing the spacing and how it should be

done, it certainly should be this Association, and I believe we should not drop this matter without giving it more serious attention than we have to-day.

Mr. E. W. Pratt (C. & N.-W. Ry.): Mr. President, I think Mr. Walsh's remarks are very opportune. It occurs to me that the chairman of this committee may have had replies from some of the larger roads that would encourage him in the belief that they should go ahead and make comparative tests, if they are not already doing so. He refers to incomplete tests during the past year, and I believe there is no doubt but that a railroad can make these tests better than the Purdue plant, having a number of boilers and parallel runs upon which such tests can be made. I should like very much to see this same committee continued, and perhaps the Chairman will see fit to make a modest inquiry of some of the larger roads as to whether they would take a hand in the comparative tests.

Mr. D. R. MacBain (Mich. Cent. R. R.): Mr. President, the question under discussion is one that we took some action on several years ago. In 1903 we selected one Atlantic type of engine out of a total of twenty-eight that had 394 flues. We took out both flue sheets and reduced the number to 333, and put that engine into service along with others of the class. While we had all the steam we needed, we have never yet been able to satisfy ourselves that we gained anything by the reduction in number of flues. We are so well satisfied on that point that notwithstanding many new fire boxes have been put in since that time, no more engines have been changed. We found, when this engine first went into service, and received the very best care on the part of the boilermen, who were largely instrumental in having the experiments made in the first place, that she was probably giving a little better service for "hot" work, as it is called, but in persevering in the matter and applying the same methods to the engines with the narrow spacing, we found that the engine with the narrow spacing averaged just as well as the engine with the wider spacing. We have never been able to notice any decrease or increase in efficiency one way or the other. We are not satisfied that we have gained anything by making the

change, and it is not the intention at the present time to change any more engines.

MR. FULLER: I would like to ask Mr. MacBain what kind of water they used, good or bad.

MR. MACBAIN: Oh, fairly good water; some limestone, but fairly good water for our district.

MR. E. A. MILLER (N. Y. C. & St. L. R. R.): Mr. President, I am very glad to see the motion voted down to make a test at Purdue, for the reason there are so many things entering into the flue question I think it would hardly be practicable to make the test there. We find, in using the same engines on two different districts, that on one district we can get about eight months' service out of a set of flues and on another district we will get from eighteen to twenty-four months' service, with the same class of engine, the flues applied by the same men, showing that the water conditions have more bearing on the flues than the spacing or the applying of the flues; and until we can overcome the water conditions we will have troubles with our flues. A service test, to my mind, is the only test that could be practically carried out to determine satisfactorily the best method of handling flues, for it is evident that what will do very well on one district will not answer on another district.

MR. W. G. MENZEL (Wis. Cent. Ry.): I fully agree with Mr. Walsh that this subject is too important to be dropped in this manner. I consider that flue spacing affects the coal consumption directly, and is one of the most important problems we have been working on. We have been going to a lot of expense in superheating, compounding, and so on, in order to save fuel, and I believe that there is a chance to save fuel in the proper spacing of flues. I think we ought to determine what is the best, and it ought to be done in service tests if possible.

MR. GAINES: I would like to make an amendment to the motion, Mr. President, that we receive the report of the committee and that the committee be continued for another year, to report again on the same subject.

THE PRESIDENT: Perhaps Mr. Smith would accept that.

MR. SMITH: With the consent of the seconder, I would

accept it. My only object in making the motion at all was that I thought we had had a pretty full discussion of it, and we might save some time. It is simply a matter of conditions, as I look on it, that each road will work out for itself.

THE PRESIDENT: The motion, then, is that the report be received and the committee be continued. (Carried.)

THE PRESIDENT: The secretary has one or two announcements to make.

SECRETARY: I have this letter from the Pennsylvania Railroad:

ALTOONA, PA., June 13, 1907.

Mr. Joseph W. Taylor, Secretary, American Railway Master Mechanics' Association and Master Car Builders' Association:

DEAR SIR,— Please announce to the railroad members of the Associations that if they will hand you their names, with the names of their families accompanying them, the West Jersey & Seashore Railroad Company will be glad to issue transportation good over its lines during the conventions.

Also, kindly notify the railroad members wishing transportation home over the lines of the Pennsylvania Railroad Company or the Pennsylvania Lines to hand you their names.

Owing to the requirements of the law, this transportation must be limited to bona-fide railroad officers and can not include members of boat lines, car lines or switching roads operated by industries.

Yours truly,

A. W. GIBBS,
General Supt. M. P., P. R. R. Lines East of Pgh.
D. F. CRAWFORD, Per G.,
General Supt. M. P., Penna. Lines West of Pgh.

THE PRESIDENT: We will now go back to the paper on "Shop Cost Systems and the Effect of Shop Schedules upon Output and Cost of Locomotive Repairs." Mr. Emerson has kindly agreed to present that paper, in the absence of Mr. Lovell. The paper is as follows:

SHOP COST SYSTEMS AND THE EFFECT OF SHOP SCHEDULES UPON OUTPUT AND COST OF LOCOMOTIVE REPAIRS.

BY MR. A. LOVELL, Supt. M. P., A. T. & S. F. Ry., Chicago, Ill.

The problem of determining shop costs is a very intricate one, and one that railroads in general have not gone into in detail. Keeping trains moving and handling the business presented has so fully occupied the time of railroad officials that the problem of determining cost accurately has been left for a future date.

General principles have been: Get the engines through the shop, keep the pay-roll down, and do the business. Increased capacity has been more important than superior economy. Some roads undoubtedly are better than others in some things, but a comparison of cost sheets will show such decided differences in cost that the only conclusion to be drawn is that different methods are employed in determining costs.

As far as shop costs are concerned, differences as to engine repair costs may arise from doing a large part of the labor of finishing material on shop or store orders. When an engine comes into the shop, this finished material is drawn from the store department and applied to the engine. The value of this will then all appear as material, and the labor cost of the engine getting the finished material will be reduced a corresponding amount.

As an example, the total cost of engines, including labor and material, through two large shops of different systems, was as follows for the same month:

	Labor.	Material.	Total.
Road "A"	$21,667.10	$22,323.64	$43,990.74
Road "B"	28,259.64	15,180.49	43,440.13

The total output of engines was practically the same in each shop and the total difference in cost of engines was only $540.00 on the month's output, yet on one road the labor charge was $6,592.00 less than on the other. This is probably a case where there was a difference in the method of determining costs.

The surcharge or amount to add to direct labor charge is another item of variance.

Every road distributes direct labor or pay-roll to engines and shop orders. This is easy. Almost all roads add something to this to cover expense of handling. Some roads are looking into the question of going still further and adding to the cost of the shop output all the items of cost that make up the total expense of running the shop. This is an intricate problem, and, while all agree that items such as rent, supervision,

machinery, power, heat, light, water, etc., enter into the cost of the shop output, few are attempting to distribute these items.

Railroads determine costs principally for the purpose of making comparisons between different shops on their lines and also to compare costs in the same shop from year to year.

A commercial concern must distribute all its costs to the value of the output so as to determine the selling price. Railroad shop accounting from the mechanical standpoint is different. The railroad is only after a comparative figure to compare one year with another or one shop with another.

If the cost of running the power plant is kept as a separate item, we can follow this from year to year and bring pressure to bear to improve it when possible. There is no reason why this item should enter into the cost of repairing engines unless it is desired to compare the cost of what is being done in the railway shop with the price for which some outside concern is willing to do the same work.

It would be well if the cost of the output was determined accurately and scientifically; but as the railroad shops can continue to run efficiently without taking up this special matter, and as no two experts agree as to the best method of actually making the distribution of the surcharge, it is not likely that the matter will be taken up very seriously for some time to come. It is an accounting matter and does not affect relative costs of repairs at different periods and shops on any one road.

Repair shops having been built, the machinery installed and the power plants running, the expense of maintenance will continue as a constant charge; and it is immaterial, as far as comparative costs are concerned, whether they are divided into small quantities and distributed, or allowed to remain in one lump sum.

The objects of making a complete distribution of all surcharges, then, is to determine the advisability of buying certain few articles on which manufacturers may desire to compete, and also to determine the economy of purchasing new machinery, making shop extensions, etc.

In its present stage this is a matter for the accounting department to thrash out. When accountants are more united as to how all overcharges should be handled, it will then be proper to take the matter into more earnest consideration. For the present, officers of the mechanical department are principally concerned in keeping the pay-roll down and increasing the number of engines turned out of the shops, resulting in a reduction in repair cost per ton mile of traffic handled.

Another point in the matter of accounting that all are trying to solve is a fair unit of shop output on which to base costs. The number of engines turned out, which is the unit commonly used, is misleading and crude, as some engines require more work than others, some are heavier than others; no two, in fact, require exactly the same units of work to be performed on them. A solution of this is to determine total output of the shop in standard units, a standard unit being the amount of work

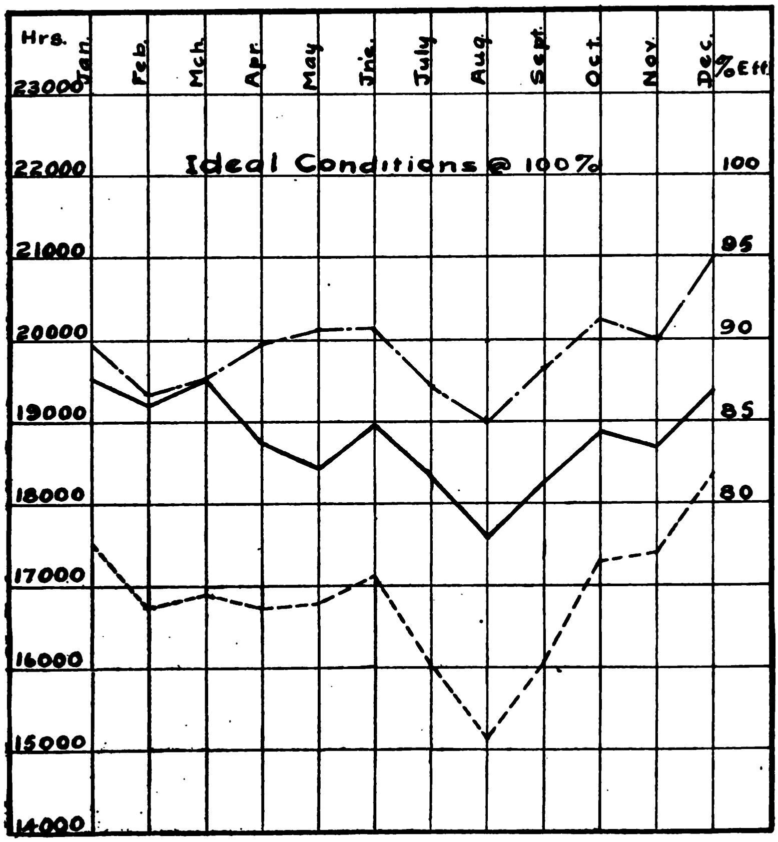
that a standard workman performs in one hour. This determination of standard units performed necessitates complete schedules of every job, but instead of having the schedule show price per job, these schedules show standard units or hours per job.

To determine the total standard units or hours of output the schedule or standard times on every operation performed must be added together. Having determined the standard units of output, we can also determine the efficiency of the shop, as the ratio of actual hours worked to standard units or hours turned out is the efficiency of the shop. This gives a perfect basis for comparing one shop with another, one gang with another or one individual with another.

The diagrams shown represent graphically standard units or hours and actual hours worked.

No. 1 for a complete shop by months.

Nos. 2, 3, 4 for individual workmen by days.



GRAPH SHOWING PERFORMANCE OF SHOP.

Heavy line represents actual number of units paid for on pay-roll. Dotted line represents actual units turned out. The ratio of the units performed to the standard units being the efficiency of the shop. Dot and dash line represents efficiency.

FIG. 1.

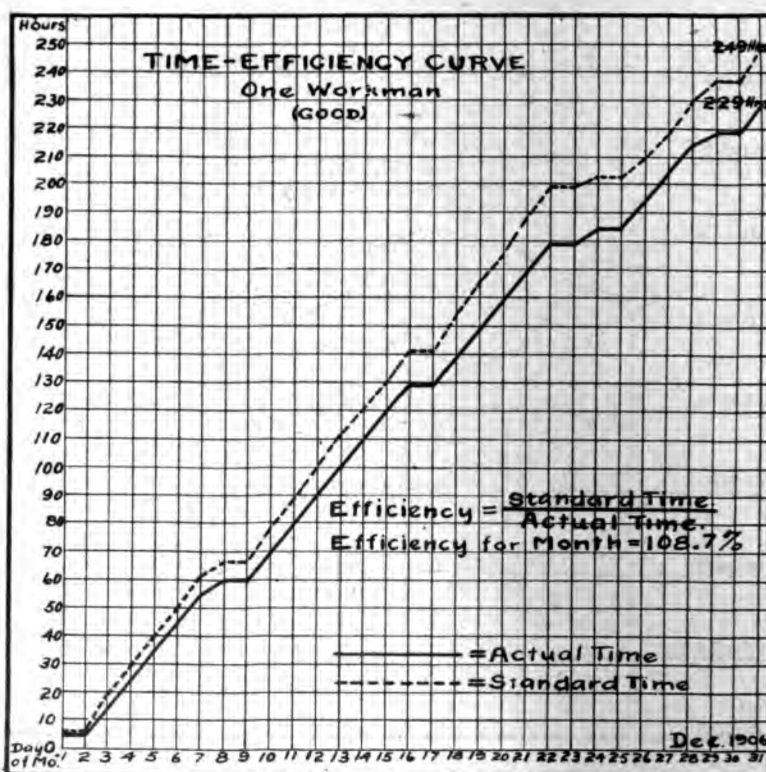
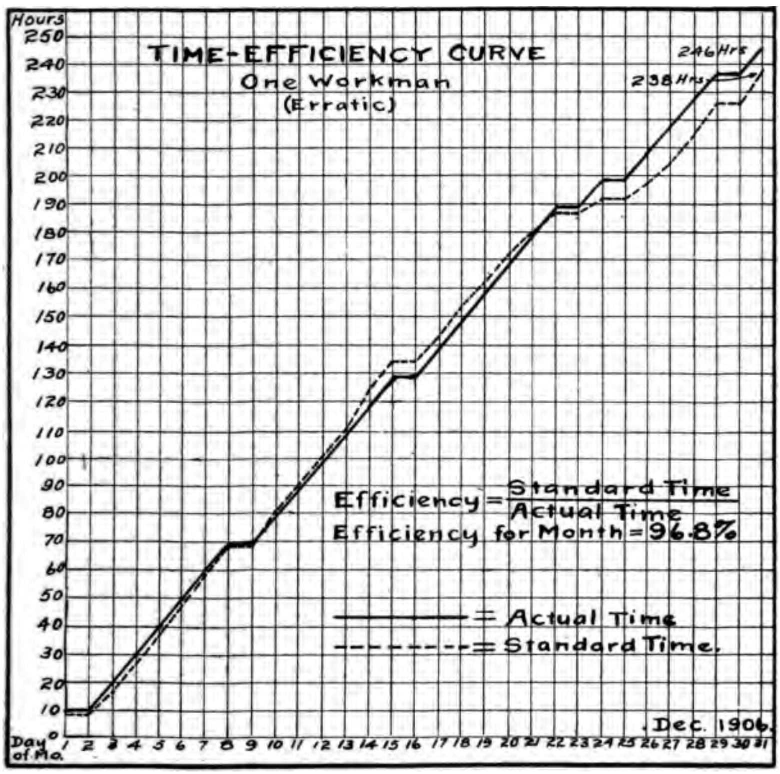

TIME-EFFICIENCY CURVE
One Workman
(GOOD)
Hours
249 Hrs
229 Hrs
Efficiency = Standard Time / Actual Time.
Efficiency for Month = 108.7%
= Actual Time
= Standard Time
Dec. 1906
Day of Mo.

FIG. 2.



TIME-EFFICIENCY CURVE
One Workman
(Erratic)
Hours
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Day of Mo.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
246 Hrs
238 Hrs
Efficiency = Standard Time / Actual Time
Efficiency for Month = 96.8%
= Actual Time
= Standard Time.
Dec. 1906.

FIG. 3.

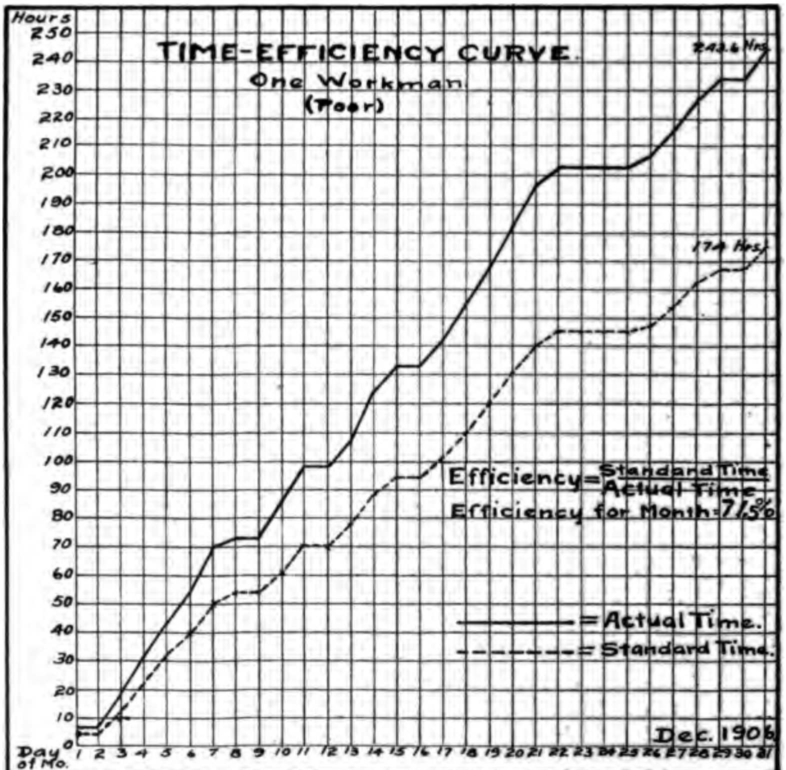

TIME-EFFICIENCY CURVE.
One Workman.
(Poor)
Hours
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Day of Mo.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
242.6 Hrs.
174 Hrs.
Efficiency = Standard Time / Actual Time
Efficiency for Month: 71.5%
= Actual Time.
= Standard Time.
Dec. 1906

FIG. 4.

ENGINE SCHEDULES.

Scheduling of engines through shops will have a decided influence to keep everything moving and save delays due to one department waiting on another.

Engine schedules must be made very carefully. It is as much of a task to make out the schedules for a shop as it is to make out the time card for a division. The schedules that work satisfactorily in one shop will no more apply to another than time cards can be exchanged. Care must be used or it will happen that some one gang or machine will be crowded with more work to be done at one time than it is possible to accomplish. This brings about a condition somewhat analogous to that on a single-track road when an effort is made to put too many trains on the same siding at once. It can not be done, and, instead of keeping up to the schedule, everything will be delayed until the necessary switching and see-sawing has been accomplished and the track is cleared.

Engine schedules bear the same relation to getting work through the shop that time cards do to getting trains over the line. Every possible effort is made to live up to schedule, but when everything goes wrong, the dispatcher, in the case of trains, and the general foreman, in the case of the shop, must take a hand, devise new meeting points, hold some trains back, advance others — in fact, run everything special until business is straightened out once more.

It is no more possible to keep every engine in a big shop moving on schedule time than it is to keep every train between Chicago and New York on time.

If it is found that engines are continually behind schedule, it may be due to two causes: First, the schedules are so fast that it is impossible to live up to them; second, something is wrong in the shop and needs bolstering up. The experience of those who have scheduled engines through a shop is that schedules are of little use unless some real and earnest effort is made to live up to them.

The work on engines is never twice exactly alike. Also the men in the shop are continually changing. Both of these conditions tend to prevent an even movement of engines through the shop. The best solution of this matter of varying amount of work on the engine and of varying numbers of men to do the work is to have a floating gang composed of all-around mechanics to act as a balance wheel for the whole shop. This gang should be used to jump in and bring any engine that is behind schedule up to date.

In some shops it has been found well to have this extra gang work at night; in others this gang works during the day. In either case this gang should have a light repair, unscheduled engine of their own to work on, in case they are not needed to bring some laggard up to the mark. It is only by having a floating gang to act as a balance wheel, that the work can be kept moving smoothly through the shop. One road

using this system has three classes of schedules and every engine entering the shop is placed on one of these schedules.

Schedule No. 1 for Light Repairs:

Light repairs consist of minor repairs, the cost of which, including labor and material, is more than $50 and less than $500.

Schedule No. 2 for Heavy Repairs:

Heavy repairs consist of thorough overhauling of machinery and such boiler work as can be done without placing the engine in the boiler shop. Cost of heavy repairs, including labor and material, more than $500 and less than $1,200.

Schedule No. 3 for General Repairs:

General repairs consist of thorough overhauling of machinery and applying new fire box, or other such heavy boiler repairs as may require the engine to be placed in the boiler shop. Cost of general repairs, including labor and material, to exceed $1,200.

Even with these three classes of schedules there are some adjustments required for special cases. Many times it is the train problem over again and our train has on a few extra cars. All that can be done in such cases is to do all possible to keep up to schedule, and when there is a general falling down, leave matters to the train dispatcher or shop foreman to get the train or engine through the best way possible.

Following are copies of the schedules as used in one of the shops using this system. These schedules are the result of months of study and adjustment. They correspond closely with the possibilities of the shop for which they are made, which is a well-equipped, modern shop. It should be understood that in another shop where crane service, machine efficiency, blacksmith, boiler shop and storehouse are not the same as in this shop these schedules could not be applied without adjustment.

Numbers in brackets are the numbers of the gangs doing operations specified, as shown on pages 22 and 23.

LIGHT REPAIRS

Which cost, for labor and material, more than $50 and less than $500.

FIRST DAY.

Engine in shop.
(20) Stripped.
(21) Valve bushings out.
(20) Material delivered.

SECOND DAY.

(40) Motion work forged.
(40) Springs forged.
(40) Rods forged.
(40) Tank work forged.

(40) Binders forged.
(40) Engine truck forged.
(40) Brake rigging forged.
(40) Guides, guide blocks and guide yokes forged.
(40) Piston rods forged.
(40) Valve yokes, rods and stems forged.
(40) Throttle valve and rigging forged.
(40) Crossheads forged.
(2) Valve bushings machined.
(30-1) Flues out.
(21) Valve bushings in.

THIRD DAY.

(40) Frames straightened.
(40) Grate rigging forged.
(3 or 4 & 21) Cylinders patched and bored.
(1) Motion work machined.
(1) Springs and spring rigging machined.
(1 & 2) Valve rods, yokes and stems machined.
(1 & 2) Engine truck machined.
(1 & 2) Dry and steam pipes machined.
(1) Rocker boxes machined.
(1) Tumbling shaft and bearing machined.
(1 & 2) Steam chest work machined.
(1 & 2) Cross heads, guides and guide blocks machined.
(1 & 2) Cylinder bushings machined.
(1) Piston rods and heads machined.
(40) Frames welded or new.

FOURTH DAY.

(3 or 4) Frames and decks on engine and bolted up.
(2) Rods machined.
(2) Brake cylinders machined.
(17 & 1) Cab work machined.
(1 & 2) Brake rigging machined.
(2) Tires turned — wheels ready.
(2) Eccentrics and straps machined.
(1 & 2) Throttle valve and steam pipe tested.
(21) Cylinder heads up.
(12) Driving boxes on axle.
(18) Tumbling shaft up.
(21) Cylinder bushings in.
(10) Air pump and engineer's valve ready.
(1 & 2) Binders machined.

FIFTH DAY.

(12) Shoes and wedges laid off.
(30 & 31) Ash pan ready.
(52) Cab and running board ready.
(18) Rocker boxes up.
(23) Engine truck ready.
(18) Reverse lever and reach rod up.
(16) Steam chest work completed.
(52) All carpenter work completed.
(21) Guides, yokes and blocks up.
(1) Shoes and wedges planed.
(21) Pistons ready.
(1) Grate rigging machined.
(16) Valves, rods and stems on engine.
(14) Brake cylinders up.
(24) Throttle valve and rigging up.
(11) Dry pipe in engine.
(14) Springs up.

SIXTH DAY.

(30-2) Flue sheets, flues and stays in.
(24) Check valves in.
(3 or 4) Boiler tested.
(30-2) Boiler work completed.
(12 & 19) Engine wheeled.
(28) Engine trucks on engine.
(52) Lagging on.
(52) Cab and running board on engine.
(24) Cab work on engine completed.
(11) Dry and steam pipe and nozzle in.
(11) Cylinders blown out.
(21) Pistons in engine.
(12) Shoes and wedges and binders up.
(23) Front end up.
(41) Headlight up.
(7) Eccentrics and straps on shaft.
(30-3) Ash pan up.
(5 & 31) Tank ready.
(7) Motion work up.
(22) Rods ready

SEVENTH DAY.

(14) Brakes and brake rigging up complete.
(23 & 52) Pilot and beam on engine.
(6) Pipe work completed.

(41) Jacket on.
(15) Grate rigging on engine.
(7) Valves set.
(22) Rods up.
(3 or 4) Engine out of shop.
(17) Pops set.
Break in.
(70) Engine and tank painted.
Engine in service.

No one engine, shopped for light repairs, requires all the work outlined in the above schedule, but each engine receives such items of the schedule as its condition may necessitate.

HEAVY REPAIRS

On which cost for labor and material is more than $500 and less than $1,200.

FIRST DAY.

Engine in shop.
(20) Wheels out from under engine.
Rods removed.
Driving boxes removed.
Pistons and guides removed.
Ash pan down and delivered to departments.

SECOND DAY.

All material delivered.
(20) Engine stripped.
(21) Valve bushings out.
(20) Respective parts delivered to their respective departments.

THIRD DAY.

(2) Valve bushings machined.
(2) New cylinders machined.
(30) Flues out.
(43) All machinery cleaned.
(30) Smoke arch removed.
(30) Stay bolts inspected.

FOURTH DAY.

(40) Frames welded, or new, or straightened.
(40) Valve rods, yokes and stems forged.
(40) Throttle rigging forged.
(40) Motion work forged.
(40) Grate riggings forged.
(3-4) Cylinders patched.

FIFTH DAY.

(21) Valve bushings in.
(1-2) Frames and decks machined.
(1-2) Eccentrics and straps machined.
(1-2) Steam chest work machined.
(1-2) Cylinder bushings machined.
(1-2) Valve rods, yokes and stems machined.
(40) Piston rods forged.
(21) Cylinders bored.
(40) Guides, guide blocks and guide yokes forged.

SIXTH DAY.

(40) Brake rigging forged.
(40) Springs and rigging forged.
(40) Rods forged.
(1-2) Driving boxes machined.
(1-2) Tumbling shaft and boxes machined.
(1-2) Steam and dry pipes machined.
(1-2) Guide yoke machined.
(1-2) Throttle valve and rigging machined.
(6) Brake cylinder machined.
(3-4) New cylinder up.
(21) Cylinder bushings in.
(3-4) Boiler on frame.

SEVENTH DAY.

(1-2) Cab work machined.
(1-2) Cylinder heads machined.
(3-4) Guide yoke up.
(3-4) Frames and decks on engine, and bolted.

EIGHTH DAY.

(1-2) Rocker boxes machined.
(1-2) Crossheads machined.
(1-2) Spring and brake rigging machined.

(1-2) Guides and blocks machined.
(1-2) Piston rods and heads machined.
(40) Engine truck work forged.
(40) Binders forged.
(14) Brake cylinders up.
(21) Back cylinder heads up.
(2) Wheels ready.
(1) Machine work for link gang.
(1) Machine work for guide and piston gangs completed.
(40) All forged work done.
(21) Guides and crossheads ready.
(18) Rocker boxes ready.
(18) Tumbling shaft ready.
(18) Reverse lever and reach rod ready.
(25) Wheels ready.

NINTH DAY.

(1) Grate rigging machined.
Binders machined.
(18) Rocker boxes up.
(18) Tumbling shaft up.
(18) Reach rod and reverse lever up.
(21) Guides up.
(30) Flue sheets and stay bolts in.
(30) Flues in.
(1-2) Machine work for rod gang completed.
(3-4) Running board brackets up and lined.
(3-4) Cab on.
(52) Cab and boards on engine.

TENTH DAY.

(24) Fitting for test on and up.
(11) Throttle valve up.
(11) Throttle rigging up.
(11) Dry pipe in engine.
(3-4) Boiler tested.
(30) Boiler work completed.
(1-2) Engine truck work machined.
(12) Shoes and wedges laid off.
(1-2) Miscellaneous machine work completed.
(16) Steam chest work ready.
(13) Drill press work done.
(3-4) Truck equalizer fulcrum up.
(3-4) Center casting up.

ELEVENTH DAY.

(14) Springs up.
(7) Eccentrics and straps on axle.
(23) Engine truck ready.
(16) Steam chest work up.
(52) Lagging on.
(1) Shoes and wedges planed.
(3-4) Floor work before wheeling completed.
(12) Driving box work before wheeling completed.
(18) Motion work ready.
(11) Steam pipe bench work done.
(29) Drilling and reaming gang completed.

TWELFTH DAY.

(3-4) Engine wheeled.
(12) Binders on engine.
(21) Pistons ready.
(41) Jacket on.
(11) Exhaust on.
(11) Steam pipes in.
(11) Steam pipes tested.
(3-4) Air pump up.
(18) Motion work up.
(24) Cab fittings ready.
(17) Cab fittings ready.

THIRTEENTH DAY.

(21) High pressure cylinders on.
(24) Cab fittings on engine completed.
(21) Pistons in engine.
(7) Valves set.
(30) Ash pan up.
(23) Front end and door on engine.
(22) Rods ready.
(31-5) Tank ready.
(14) Brake bench work done.
(15) Grate rigging up.

FOURTEENTH DAY.

(22) Rods on engine.
(9) Pipe work completed.
(52) Pilot and beam on engine.
(14) Brake rigging up, complete.
(3-4) Engine out of shop.

(23) Pilot braces, coupler, drawbar, etc., up.
(70) Engine painted.
(30) Front end in.

FIFTEENTH DAY.

(3-4) Engine broke in.
(3-4) Engine in service.

GENERAL REPAIRS

On which cost for labor and material is more than $1,200.

FIRST DAY.

Engine in shop.
(20) Engine off of wheels.
Driving boxes off and delivered to department.
Ash pan down and delivered to machine department.
Pistons out and guides down delivered to pot.
Valves and chest removed and delivered to pot.
Rods removed and delivered to pot.

SECOND DAY.

(4-c) Valve bushings out.
(20) Boiler to boiler shop.
(20) Engine stripped.
(41) Jacket off.
(52) Lagging off.
(20) Cab set on outside.

THIRD DAY.

(30) Flues out.
All material delivered.
(30) Radial stays ordered.
(30) Disconnect box.
(30) Stay rods removed.
(43) All machinery at pot.

FOURTH DAY.

(40) Frames welded or new.
(30) Back end off.
(43) Machinery cleaned.
(30) Smoke arch and ring off.
(30) Mud drum removed.
(30) Dome ring removed.

FIFTH DAY.

(40) Frames straightened.
Frames out of forge.
(30) Stays and radial stays broken.
(30) Crown bars removed.
(30) Burrs backed out.
Fire box knocked down complete.

SIXTH DAY.

(2) New wheels on axles.
(40) Radial stays forged.
(30) New material layed off.
(30) Mud ring to blacksmith department.
(30) Crown bars cleaned.

SEVENTH DAY.

(40) Motion work forged.
(40) Guide yokes forged.
(30) Side and crown sheet machined.
(30) Side casings and wagon top machined.
(30) Flues repaired.

EIGHTH DAY.

(40) Rods forged.
(40) Springs forged.
(40) Blades forged.
(40) Brake rigging forged.
(1) Radial stays machined.
(30) Fire box material flanged.
(30) Mud ring machined.

NINTH DAY.

(40) Binders forged.
(40) Grate rigging forged.
(40) Engine truck work forged.
(1-2) Steam chest work machined.
Valve rods, yokes and stems machined.
(30) Fire box assembled.
(30) Smoke arch ready to go on.

TENTH DAY.

(2) Frames and decks machined.
(1-2) Springs.
Brake rigging.
(40) Guide blocks forged.
(40) Piston rods forged.
(30) Smoke arch on.
(30) Fire box riveted.

ELEVENTH DAY.

(17) Radial stays machined.
(30) Fire box put on.
(30) Connection holes reamed.
(30) Boiler check castings put on.
(30) Dome ring put on.
(30) Miscellaneous patching complete on shell.

TWELFTH DAY.

(1-2) Motion work machined.
(30) Connection made complete.
(30) Corner rivets put in.
(30) Stay bolt holes tapped out.
(30) Radial stays received.

THIRTEENTH DAY.

(40) Throttle valve rigging forged.
(3-4) Cylinders patched.
(1-2) Cylinder heads machined.
(1-2) New cylinders machined.
(40) All forge work completed.

FOURTEENTH DAY.

(1-2) Valve bushings machined.
(1-2) Rods machined.
(1-2) Cylinder bushings machined.
(1-2) Engine trucks machined.
(21) Cylinders bored.

FIFTEENTH DAY.

(21) Valve bushings in.
(1-2) Throttle valve machined.
(1-2) Guides and guide blocks machined.

(1-2) Crossheads machined.
(1-2) Dry and steam pipes machined.
(21) Cylinder bushings in.

SIXTEENTH DAY.

(3-4) New cylinders up.
(17) Cab work machined.
(1) Driving boxes machined.

SEVENTEENTH DAY.

(2) Wheels ready.
(21) Back cylinder heads up.
(30) Radial stays driven, complete.
(30) Stay rods put in.
(24) Washout plug holes tapped out.

EIGHTEENTH DAY.

(30) Flue sheets in.
(6) Brake cylinders machined.
(1-2) Guide yokes machined.
(1-2) Rocker boxes machined.
(1-2) Eccentrics and straps machined.
(20) Boiler to erecting shop.
(1) Machine work for links.

NINETEENTH DAY.

(3-4) Frames and decks on engine, and bolted up.
(11) Throttle valve and rigging up.
(30) Fire box completed.
(11) Check valves in.
(24) Dry pipes in engine.
(16) Steam chest work ready.
(24) Fitting for test up.
(18) Rocker boxes ready.
(18) Tumbling shaft ready.
(18) Reverse lever and reach rod ready.
(3-4) Running board brackets up and lined.

TWENTIETH DAY.

(18) Rocker boxes up.
([illegible]) Brake cylinders up.
(30) Boiler work completed.
([illegible]) Boiler tested.
([illegible]) [illegible]

(16) Valve rods, yokes and stems on engine.
(1-2) Grates and rigging machined.
(16) Steam chest work up.
(1-2) Pistons, rods and heads up.
(12) Shoes and wedges laid off.
(1) Machine work for driving box and guide and piston gangs complete.
(21) Guides and crossheads ready.

TWENTY-FIRST DAY.

(14) Springs up.
(52) Lagging on.
(21) Guides up.
(52) Cab and boards on engine.
(7) Eccentrics and straps up.
(23) Engine trucks ready.
(18) Tumbling shaft up.
(18) Reach rod and reverse lever up.
(3-4) Floor work before wheeling.
(1-2) Miscellaneous machine work.
(12) Work before wheeling.
(18) Motion work done.
(18) Drill press work done.
(29) Drilling and reaming gang complete.
(3-4) Cab on.

TWENTY-SECOND DAY.

(3-4) Engine wheeled.
(41) Jacket on.
(12) Binder up.
(18) Motion work up.
(24) Cab fittings ready.
(17) Cab fittings ready.

TWENTY-THIRD DAY.

(3) Air pump up.
(14) Brake rigging ready to put up complete.
(21) Pistons ready.
(7) Valves set.
(15) Grates and rigging up.
(30) Ash pan up.
(24) Cab work on engine completed.
(23) Front end and door on engine.
(22) Rods ready.
(11) Steam pipe bench work done.

TWENTY-FOURTH DAY.

(21) Cylinders blown out.
(21) Pistons in engine.
(21) Front cylinder heads up.
(11) Steam pipes tested.
(22) Rods on engine.
(52) Pilot and beam up.
(5) Tank ready.
(14) Brake rigging up complete.
(11) Steam pipe work up.

TWENTY-FIFTH DAY.

(9) Pipe work completed.
(3-4) Engine out of shop.
(23) Pilot braces complete, drawbar, etc., up.
(70) Engine painted.
(30) Front end in.
(3-4) Engine broke in.

TWENTY-SIXTH DAY.

(3-4) Engine in service.

These schedules cover practically every detail job to be done on an engine. It was only after many additions had been made that each detail was covered as completely as at present, and even now new points arise from time to time that have to be specified in the schedule.

The shop using these schedules is operated by the gang method and each foreman has a card showing when his particular work is to be done. At 7 o'clock each morning a written notice is handed to each foreman showing how his work stands and a summary is given to the general foreman showing how all the work stands. The general foreman is also given a report showing how many and what class of workmen each gang is short. By comparing the work report with the labor report he is able to assign men from the floating gang to gangs that are liable to fall behind. This method passes engines through the shop with the regularity of mail train service and, combined with a system of rigid inspection and assignment of work, gives the minimum delay with the minimum cost for repairs.

Scheduling of Engines:

1. Saves confusion and bunching of work.

2. Aids the general foreman to exercise a much better supervision over gangs that are in trouble.

3. Prevents waste of energy by one gang doing work at a time, or in a way, that will interfere with other gangs.

4. Permits the placing of responsibility immediately and correctly on he gang or gangs responsible for an engine delay.

Scheduling in itself will not reduce costs except to the extent that alse moves are cut out, and, in general, increased shop output or efficiency neans reduced cost.

Scheduling does, however, reduce costs when supplemented by the ollowing system of keeping account of labor charges.

Each engine coming into the shop is thoroughly inspected to determine hat repairs ought to be made. The inspector's report is made out, showng in detail just what each gang is to do. In addition, the cost of this work is estimated in detail for each gang.

The work to be done by each gang is written up and handed to the oreman. The following is a copy of the work slip given to the foreman f the guide and piston gang for Engine 429 passing through the shop for eneral repairs in February:

WORK TO BE DONE ENGINE 429, GENERAL REPAIR.

Guide and Piston Gang No. 21.

"Order new right piston complete; right front cylinder head and oth right cylinder casings; material now on shop order. Bore both ylinders; just clean them up. Order new left piston complete; crossead keys; new nuts on crosshead pins; new side liner on crosshead; all ew cylinder packing. New piston rod packing and vibrating cups. Hang he guides; put in pistons and see that they have proper cylinder clearance. 'ut up heads and casings. Put oil cups on guides."

All the gangs in the shop are numbered, the following being the comlete list:

GANG.	NAME OF GANG.
1	East machine shop.
2	West machine shop.
3	East erecting floor.
4	West erecting floor.
5	Tank truck.
6	Air brake.
7	Valve.
9	Pipe.
10	Tool room.
11	Steam pipe.
12	Driving box.
13	Drill press.
14	Spring and brake.
15	Grate.
16	Steam chest.
17	Brass room.

GANG.	NAME OF GANG.
18	Link.
19	Crane.
20	Stripping.
21	Guide and piston.
22	Rod.
23	Engine truck.
24	Cab fittings.
25	Yard laborers.
28	Floating.
29	Drilling.
30	Boiler.
30-1	Boiler shop — flue.
30-2	Boiler erecting floor.
30-3	Ash pan.
30-4	Steel cab.
31	Tank boiler work.
35	Sweepers.
40	Forge.
41	Tin shop.
43	Wheel and axle shop.
47	Electricians.
52	Locomotive carpenters.
56	Upholstering.
70	Paint.

The timekeeper charges all of the floor time to both engine and gang numbers.

When the engine leaves the shop the cost of each separate gang is figured as soon as possible and a report furnished the Shop Superintendent, showing the total gang charges to each engine, together with estimated charges.

This furnishes him with just the data needed in order to determine which gangs are spending money economically and which are wasteful. He has the estimate of what each gang should have cost and the record of what the gang did actually cost. When there is a discrepancy, the foreman is called to account. Following is a copy of the report rendered for Engine 429:

ESTIMATED AND ACTUAL LABOR COST FOR ENGINE NO. 429 ASSIGNED TO WEST ERECTING FLOOR FOR GENERAL REPAIRS.

GANG.	ESTIMATE.	ACTUAL.
1	$ 65	$ 59.73
2	28	30.70
3 or 4	175	189.08

GANG.	ESTIMATE.	ACTUAL.
5	28	25.48
6	3	2.60
7	20	20.91
9	30	27.88
10	2	.84
11	25	25.67
12	20	25.78
14	30	32.84
15	10	5.09
16	15	13.03
17	20	22.22
18	30	30.81
19	10	11.88
20	27	27.69
21	40	41.25
22	31	31.16
23	20	19.20
24	20	18.70
25		7.61
30	440	423.41
31	3	3.61
35	5	4.62
40	175	179.28
41	13	13.32
43		.73
47	3	2.94
50		.20
52	25	26.77
56		1.54
70	20	20.64
Supv. bonus, etc.	320	373.56
Total	$1,653	$1,720.77

The gang estimated and actual costs ran very near together in this case. The gangs are held down very rigidly and not allowed to do any work not called for on their work slip. If a gang foreman finds, after the engine is in the shop, some work to be done not called for by his work slip, he must report this to the inspector, who will allow and authorize an extra expenditure to cover the extra work, if he deems it necessary. It is by this close watch that a large saving in labor can be effected, as it prevents unnecessary work being done and makes the inspector responsible for everything done to the engine. Foremen who are inclined to build an engine like a watch are restrained, while those who are inclined to slight their work are spruced up.

The scheduling and keeping track of costs as described above means increased output, because the individual worker is being watched more closely. He is not forced to work any harder than without it, but is prevented from making false moves, getting in the way of other workers, and from doing unnecessary work.

The total output of the shop is the sum of the output of each individual worker. This should constantly be borne in mind, and no system adopted that will not help each individual worker, as he is the man on whom the output depends.

Mr. H. Emerson: Mr. President, in the absence of Mr. Lovell, I have been asked to abstract this paper. The reason is, probably, that for three years I was intimately associated with him in this work in his department. It is a welcomed opportunity to express publicly the great obligations I am personally under to him for what was finally accomplished. Some men are of assistance by helping one to build up and do right; others are of not less valuable assistance in preventing one from going wrong. Mr. Lovell has one of the keenest minds I ever met in detecting the weak spots, the faulty links in any plan, and time and time again his criticisms made it necessary to pause, to start over again, to amend and to correct. Mr. Lovell was from Missouri — he had to be shown; but when at last he was convinced, there was no one more willing to support, to defend, if need be, than himself. This paper of his outlines some fundamental principles on which we finally agreed, and rejects others that he is not yet prepared to accept. Without disloyalty to him, I may in the discussion be permitted to come to the defense of what he is still unwilling to accept.

The paper being in your hands, I shall abstract it very briefly. The main idea in schedule work and costs in a locomotive shop is to make common sense compulsory. The work falls into three parts, the scheduling of all the work, whether as to engines or as to the work of the individual men, the standardizing of time for all work, and the standardizing the cost of all work. On page 21 is a summary of the advantages of scheduling all work. This applies as much to other work as it does to engines. It saves confusion and the bunching of the work; it aids the general foreman to exercise a much better supervision over men that are in trouble; it prevents waste of energy by one gang doing work

at a time or in a way that will interfere with other gangs, or one man doing work in a way that will interfere with the work of another man. It permits the placing of responsibility immediately and correctly. Scheduling in itself will not reduce costs, except to the extent that false moves are cut out, and in general increased shop output or efficiency means reduced cost. If it is possible to cut out the waste of time and waste of effort generally about thirty per cent, that cost can be eliminated. Scheduling does, however, reduce costs when supplemented by the following system of keeping account of labor charges. Each engine coming into the shop is thoroughly inspected to determine what repairs are to be made. The inspector's report is made out, showing in detail just what each gang is to do. In addition, the cost of this work is estimated in detail for each gang. The work to be done by each gang is written up and handed to the foreman.

Also, on page 25: "The scheduling and keeping track of costs as described above means increased output, because the individual worker is being watched more closely. He is not forced to work any harder than before, but is prevented from making false moves, getting in the way of other workers, and from doing unnecessary work. The total output of the shop is the sum of the output of each individual worker. This should be constantly borne in mind, and no system adopted that will not help each individual worker, as he is the man on whom the output depends."

Standardized time is shown from pages 8 to 21 as to the engines coming to the shop, also diagrams as to individual work, pages 5, 6 and 7. On page 5 we find a time efficiency curve of a good workman. The dotted line is the standard time of doing the work. The heavy line is the time that he actually took. Therefore he took 220 hours to do 249 hours' work, showing an actual efficiency of 108.7 per cent. On page 6 you have the efficiency curve of a somewhat erratic workman, who sometimes did better than the standard and sometimes less well. On page 7 you have the only too common diagram of the man who does much worse than he should. The efficiency in this case is only 71.5 per cent. Very often in shops there are full-paid men whose efficiency falls down to 30, 20, 15, or even 10 per cent. On page 24 is a sample of the standardized cost of repairs. It is the prac-

tice before the repairs on an engine are undertaken to standardize the whole cost necessary for those repairs. In a comparison between the estimated cost and the actual cost, taking all the engines that are repaired at that shop, the deviation between the estimated cost that is predetermined and the actual cost is not more than five per cent. There are individual engines where there is more than that, but on the whole the deviation is, as I say, not over five per cent.

At the middle of page 3 is a paragraph: "Another point in the matter of accounting that all are trying to solve is a fair unit of shop output on which to base costs. The number of engines turned out, which is the unit commonly used, is misleading and crude, as some engines require more work than others; some are heavier than others. A solution of this is to determine the total output of the shop in standard units, a standard unit being the amount of work that a standard workman performs in one hour. This determination of standard units performed necessitates complete schedules of every job, but instead of having the schedule show price per job, these schedules show standard units or hours per job."

The diagrams that follow show the relation between the standard unit and the actual time taken. They are, of course, summarized into a report for the whole shop, which you find on page 4. That is not an ideal diagram, but it illustrates what is meant. The heavy line is the actual time taken. The dotted line represents the actual units turned out. The line at the top represents the efficiency of the shop. You will notice that the efficiency of the shop in this case has theoretically been increasing from August to December, it being 85 per cent in August and 95 per cent in December. This is an ideal diagram; not based on actual facts.

Now, any system whatever that will produce efficiency without either antagonizing or harrowing the worker is a good one, but it is not necessary that it should be any particular kind of system. It is, however, essential if the efficiency of a shop is to be improved that there shall be some method of showing the relation between what actually is and what should be, that being the meaning of shop efficiency.

I now take up those matters in which I dissent somewhat from this report. On page 3, the third paragraph from the top of the page: "In its present stage general expense is a matter for the accounting department to thrash out. When accountants are more united as to how all overcharges should be handled, it will then be proper to take the matter into more earnest consideration. For the present, officers of the mechanical department are principally concerned in keeping the pay-roll down and increasing the number of engines turned out of the shops, resulting in a reduction in repair cost per ton mile of traffic handled."

The trouble in a great many shops is that neither the foreman nor anybody else knows the cost of the operation; does not know whether it is more economical to employ a cheap man who takes a long time, or to employ a high-priced man who takes a short time; does not know whether it is more economical to do work on a cheap machine that takes a little longer or to do it on a very expensive machine that takes a shorter time, and the consequence is that in a great many shops recommendations are made in the hope of accomplishing economy that have exactly the opposite result; that, after these so-called improvements have been put in, the costs, instead of going down, are found to have risen very materially.

To turn any matter of shop administration over to accountants is a very serious and grave mistake. The accountant has a very important duty to perform. He has been trained to show where the money goes to, but "efficiency" is not any part of his duty. The superintendent of the shop should aim at efficiency, and it is no part of his duties to follow up particularly how the money comes in or how it is spent, provided he realizes a high shop efficiency. I could well imagine on a rifle range that the man keeping the score would keep the same kind of a score whether the rifle carried a hundred yards or a thousand yards. The score in each case would be similar. But there is a tremendous difference in the value of the two rifles, whether they shoot straight at a hundred yards or at a thousand yards; and as an illustration of accounting methods, I have one in mind in which the accountants were very careful to determine that the men should be employed at a certain approved rate of wages, let us

say 38 cents for full-class machinists. They were also very strenuous that these men should be carefully checked in at 7 o'clock in the morning and checked out again at 6 o'clock in the evening, so as to be sure that the company was receiving ten hours. Finally, the accountants were very strenuous that the work of these men should be distributed to the different engines, all of which was done by the accountants in records with which no fault could be found, except that, as a matter of fact, the men, after checking in in the morning at 7 o'clock, had climbed onto an engine with a keg of beer and gone twelve miles out into the country where there was an Indian village and spent the whole day there, coming back again at about half past 5. They then distributed their imaginary time to the various engines and checked out at 6 o'clock. But the company itself had got absolutely nothing of value for the wages paid these men, and the distribution of cost to the unfortunate engines was not only valueless, but misleading.

The method of determining costs is important. The cost consists of material, of labor, of machine cost and of a departmental charge. Unless one knows as to every single item the cost of the material, the cost of the direct labor, the cost of operating the machine and the general costs of the department, it is impossible to tell whether one method is better than another; whether to charge a little more for interest or depreciation or a little less is unessential, but unless there is a correct method of determining the actual cost of each unit of work, it will be absolutely impossible in any shop whatever to bring costs down to the lowest possible point.

The question of determining costs is not one of "accounting," but one of "shop efficiency."

MR. WILLIAM McINTOSH (C. R. R. of N. J.): Mr. President, the system outlined here seems to be a fairly developed one and no doubt will afford the information that we desire. It [illegible] value of system, and whether this is the system [illegible] results or not is not material as long as it [illegible] method of reaching such information as will [illegible] follow in these lines and bring [illegible]

[illegible] can be done by system. I will

explain that in our Elizabethport shops, when we commenced to operate them, we adopted the usual plan of distributing a number of locomotives to each gang, letting them have charge of the work and proceed with it in the best possible manner according to the judgment of the gang foreman individually, and under the supervision of the erecting shop foreman. Studying the situation over, we concluded, however, that we could do better than that, and we decided to group our engines. There are now on all our large railroads many engines of duplicate design in groups of classes. We designate our engines by numbers. Taking, for instance, what we would call our 430 class engines, which are our largest type, will say we have a hundred of them; that means that there are always as many engines of that class going through the shop as one gang can handle. We therefore decided to give a class to a gang, and for several years past that class of engines has been repaired by the same gang. It works on no others. Then we have another class coming along that we assign to another gang, and we pass all our engines through the shop in that manner, aiming so far as it is possible, and it is largely possible, to have gangs working on the same kind of engines day in and day out, week, month and year in and out; so that they become perfectly familiar with every piece of machinery, and consequently can handle the work to much better advantage. It is easily seen how there must be a great advantage in doing that, over having in a gang a half dozen engines of different makes, and I am sure that wherever that system is introduced and followed up it will be found to work out to extraordinary advantage.

MR. H. H. VAUGHAN (C. P.): Mr. President, before this discussion is closed I would like to give expression to our gratitude to Mr. Lovell for this paper. It appears to me that Mr. Lovell has described a system of shop costs — I do not know whether it is new to all the members, but it certainly is very new to me — which is one of the neatest and most complete arrangements that has ever been brought out, to my knowledge, in the direction of keeping track of men's efficiency. Some years ago, in operating a small shop, I established standard prices for all our operations, and at the end of each week, which was our accounting period, each foreman was notified of a list of the operations

which had been completed above the standard time and below it, so that he could check up his men. That was a sort of a mixed-up system in that we did not keep any continuous record of the man's efficiency or of a department's efficiency. Now Mr. Lovell has supplied the key to make one of these operation cost systems practical and useful by taking the standard time or cost, practically the standard time, on each job and compiling the figures for each man each month and then for all the men each month, and thus we have a system which appears to me, after thinking over this paper, probably equal to any piecework system we could devise. In a good many of our smaller shops piecework systems are difficult. The work comes along in such a way that it does not allow of piecework systems being satisfactorily introduced, and those shops are being judged very largely on their output of general repairs or output of intermediate repairs, and we have no way of judging of them. Some time ago, when I was on the Lake Shore, we were asked, as a committee of the New York Central Lines, to get up some system of comparing the output of different shops. We were immediately struck with the difficulty that always has been experienced in that connection — that a man could always get increased output by neglecting his repairs. One man can do repairs much cheaper than the other fellow if he does not do them as well. Now, Mr. Lovell's system compares these things, unit by unit, and groups them together to form a complete engine, so that if one man does an engine for 110 per cent and another for 90 per cent, you have a direct measure of the efficiency of those two jobs, based really on what would be equivalent to piecework prices for each little job done, if I understand that correctly, Mr. Emerson?

MR. EMERSON: That is correct.

MR. VAUGHAN: Yes. Well, we have never had a system brought before this Association that would enable you to do a thing of that sort before. We have never had a system for keeping track of each man's efficiency, or each gang's efficiency, in the way that this system does. I think this is one of the most remarkable papers that we have ever had in that sense. It shows us a way of coherently and systematically following a man's output and a shop's output in a way in which we have never been

able to do it before, by building up from each unit a completed work. It is worthy of very careful study, and for my part I do not see why a road that is working some shops piecework and other shops daywork could not use this system to put their piecework prices right into the daywork shops and have some measure of these smaller shops and shop efficiencies where at present they have no system except a general rough idea of the number of engines turned out each month.

A card plotted like Fig. 1 would be a simple and easy way of keeping track of the output from each shop and measuring up shops, irrespective of whether they give their engines general or light repairs, or anything else.

With regard to the surcharge question, I can see what Mr. Emerson means about the value of really getting into the surcharge. It seems, however, that railroads are being run to a certain extent differently from manufacturing concerns. Our accounts are dominated by the general accounts of the road, the distribution of these accounts is pretty well determined by the Interstate Commerce Commission, and we have certain accounts, such as superintendence, fuel and light for shops, repairs to tools and machinery, etc., which are separate from the repairs to locomotive accounts by a general agreement. Now, where these accounts can be best distributed in proportion to the labor, there is, I think, no object whatever in railroad accounting in adding that onto the cost of the work. For instance, repairs to tools and machinery at a shop can not be prorated on to individual jobs or individual tools, or without a very large amount of accounting can only be distributed as a certain percentage on the labor; there is no object in adding this onto the cost of the work.

The thing that Mr. Emerson brought out, which I agree with him on, is of importance, is a record of the investment and cost of operating tools. I think very frequently, when we get expensive bar lathes in a shop, our foremen are very apt to put work on an expensive machine and be proud to do it in twenty-five minutes, instead of an hour and a half in a lathe, when the cost of that machine altogether eats up the saving in cost of labor. To that extent I agree with Mr. Emerson. I do not believe with most of us it is of much value in prorating onto the work those

items that can only be carried as a percentage on the labor. It is easier to determine what they come to in a month, and if you are in competition with building establishments, as we are, and desire to know whether we produce our work more cheaply, we can take these percentages and add these to our cost and determine whether it pays to make material or not.

THE PRESIDENT: Is there any further discussion on this subject?

MR. G. W. WEST: I move that the discussion be closed. (Motion seconded and carried.)

THE PRESIDENT: We will now take the report of the Committee on Results of Use of Different Valve Gears.

The report was presented by Mr. Seley, chairman, as follows:

REPORT OF COMMITTEE ON RESULTS OF USE OF DIFFERENT VALVE GEARS ON LOCOMOTIVES.

To the Members:

(1) As this Association was favored at its last convention with an admirable mathematical analysis of various forms of valve gear in use on locomotives, it is evident, from the wording of the subject assigned to this committee, it is desired to present the practical considerations governing present-day locomotive engineering in regard to choice and design of valve gears and the results obtained in general practice and use. The subject is, perhaps, the least understood of all the detail mechanism of the locomotive, and while most railroad and drawing offices can produce men competent to lay out and design the ordinary type of motion, yet the builders are very generally called upon to furnish the design, subject possibly to a specification that allows and expects the builder to use his best judgment in regard to these important details.

(2) That this confidence is not misplaced is to be seen daily in the fine performance of engines the country over, in all classes of service, fast and slow, passenger, freight, work and switching.

(3) While the development of types and details of locomotives must necessarily be on railroads and under motive power official supervision, yet honor is due to Baldwin, Winans, Norris, McQueen, Rodgers, Brooks and others, who, in times past, by their mechanical ingenuity as well as business acumen, have contributed to the establishment and success of the American railway systems and more particularly to the department over which this Association exercises its activities. There are many other names of men, many of whom are still with us, deserving of mention in

an honor roll, of those who have helped to make the modern locomotive the fine example of utility, power, speed and economical maintenance as will compare favorably with the work of other nations, but we must limit ourselves to the subject in hand, which is one of the most important and vital to the success of the locomotive in whatever branch of the service it may be called upon to perform.

(4) It seems hardly worth while to spend much time going back to the early history of locomotive valve motion. While, no doubt, much could be said about the different kinds of valve motion that have been used in the past, the committee feels it should only take up the points that will be most profitable to the Association. The problems of our day are based on different conditions and have to do with vast increases of weight, power and speed over and above those of only a few years past.

(5) Without going into detail, therefore, regarding the "hook" and others of the older motions which now no longer survive, it can be stated that by far the greater number of engines in this country are equipped with what is commonly termed the Stephenson link motion. This is probably true also but in a less degree in the British Isles, but on the continent of Europe it is estimated that the Walschaert motion leads all others.

(6) The Stephenson link motion has held its own in this country, almost without consideration being given to other types, until within very recent years. The types and weights of engines employed lent themselves to convenient use of the link motion which has many desirable and valuable features to commend it.

(7) The time came, however, when it became expedient to make changes for some of the following reasons: Some types of engines have so many wheels or they are so closely grouped that it is a difficult matter for engine men to get under them except when over a pit. This contributes to neglect, lack of prompt adjustments for wear, lack of proper inspection and a more rapid deterioration. With the increase in size and weight, the dimension of eccentrics required for large axles are excessive and their peripheral speed is so great as to make maintenance and lubrication of the eccentrics and straps expensive and troublesome. In the long list of materials for this purpose appears plain cast iron; cast iron, babbitt lined; bronze; cast steel, brass lined; gun metal, etc.

(8) By the abolition of eccentrics and straps, a long list of engine failures is eliminated; expense for maintenance and lubrication reduced; room gained for better cross-bracing and strengthening of frames and adding to convenience on account of men not being required to go under engines to the same extent.

(9) On heavy engines, the weight of all moving parts of a link motion, from the eccentric straps through to the valves, is so great as to

contribute to accident and rapid wear so that an equally efficient valve motion with lighter parts and greater accessibility is in demand for heavy power.

(10) For many reasons, we can not lower the standard of efficiency as set by the Stephenson link motion. Economy in the use of coal and water are more necessary than a reduction in weight and wear of valve motion parts. No railway manager will sanction the use of a device, no matter how beautifully simple it may be, if his costs as measured in coal are increased thereby.

(11) Fortunately, we are able to obtain a valve motion having the desirable features of lighter parts and accessibility without a loss of efficiency in the Walschaert motion, which has come into extensive use the last few years.

(12) It is unnecessary in this report to describe the arrangement and detail of these motions, but we present herewith some valve motion diagrams and data furnished by the courtesy of the American Locomotive Company and the Baldwin Locomotive Works, comprising recent examples of both Stephenson link and Walschaert motions.

(13) Tables 1 and 2 are for Stephenson link motion, for freight and passenger engines respectively, the former having a short and the latter a long radius link. Tables 3 and 4 are for Walschaert motion passenger engines of two different types. Tables 5, 6 and 7 are for freight engines, medium and heavy consolidations and a decapod being presented.

TABLE 3.

VALVE MOTION REPORT. A.L.CO. ORDER NO. 1114.
BROOKS WORKS, JANUARY 25, 1907. ATLANTIC TYPE. PASSENGER ENGINE.
WALSCHAERT MOTION, 21" x 26" CYLINDERS, 78" DRIVERS.
VALVE TRAVEL $5\frac{3}{4}$", STEAM LAP 1", LEAD CONSTANT $\frac{1}{4}$".
SEE FIG. 3, VALVE MOTION DIAGRAM.

	CUT OFF POSITION		PRE-ADMISSION FRONT	PRE-ADMISSION BACK	LEAD FRONT	LEAD BACK	PORT OPENING FRONT	PORT OPENING BACK	CUT OFF FRONT	CUT OFF BACK	RELEASE FRONT	RELEASE BACK	CLOSURE FRONT	CLOSURE BACK
FORWARD MOTION		FULL GEAR	0	0			$1\frac{13}{16}$	$1\frac{13}{16}$	$21\frac{3}{4}$	$21\frac{7}{8}$	$24\frac{9}{16}$	$24\frac{9}{16}$		
	66%		$\frac{3}{16}$	$\frac{3}{16}$			$\frac{27}{32}$	$\frac{27}{32}$	$17\frac{5}{8}$	$17\frac{7}{16}$	$22\frac{7}{8}$	$22\frac{13}{16}$		
	50%	HALF STROKE	$\frac{5}{16}$	$\frac{3}{8}$			$\frac{1}{2}$	$\frac{17}{32}$	14	$13\frac{3}{4}$	$21\frac{3}{8}$	$21\frac{3}{16}$		
	33%		$\frac{9}{16}$	$\frac{5}{8}$	$\frac{1}{4}$"		$\frac{5}{16}$	$\frac{11}{32}$	$9\frac{3}{8}$	$9\frac{3}{8}$	$19\frac{1}{8}$	19		
	25%	QUARTER STROKE	$\frac{3}{4}$	$\frac{7}{8}$			$\frac{1}{4}$	$\frac{9}{32}$	$7\frac{1}{2}$	$7\frac{1}{2}$	18	$17\frac{15}{16}$		
	20%		1	$1\frac{1}{8}$			$\frac{7}{32}$	$\frac{1}{4}$	6	6	$16\frac{7}{8}$	$16\frac{3}{4}$		
BACKWARD MOTION		FULL GEAR	0	0			$1\frac{3}{4}$	$1\frac{7}{8}$	$22\frac{1}{4}$	$22\frac{1}{4}$	$24\frac{13}{16}$	$24\frac{5}{8}$		
	50%	HALF STROKE	$\frac{3}{8}$	$\frac{3}{8}$			$\frac{1}{2}$	$\frac{1}{2}$	13	$13\frac{7}{8}$	$21\frac{3}{16}$	$23\frac{1}{8}$		
	33%		$\frac{9}{16}$	$\frac{5}{8}$			$\frac{11}{32}$	$\frac{11}{32}$	9	$9\frac{5}{8}$	19	$19\frac{3}{8}$		
	25%	QUARTER STROKE	$\frac{7}{8}$	1			$\frac{1}{4}$	$\frac{1}{4}$	$6\frac{7}{8}$	7	$17\frac{1}{2}$	$17\frac{7}{8}$		

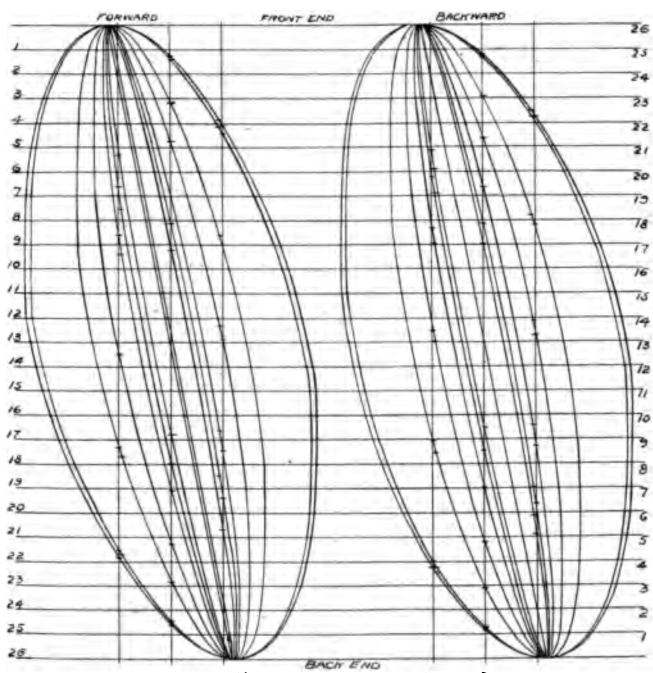


FIG. 3. WALSCHAERT VALVE MOTION DIAGRAM

TABLE 2.

VALVE MOTION REPORT. A, L, CO. ORDER NO, 1069.
BROOKS WORKS. JUNE 13, 1906. 10 WHEEL PASSENGER ENGINE.
STEPHENSON LINK. 20" × 28" CYLINDERS, 67" DRIVERS.
VALVE TRAVEL $5\frac{5}{8}$". STEAM LAP 1", LINK RADIUS 62".
SEE FIG, 2. VALVE MOTION DIAGRAM.

CUT OFF POSITION			PRE-ADMISSION		LEAD		PORT OPENING		CUT OFF		RELEASE		CLOSURE	
			FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK
FORWARD MOTION		FULL GEAR	0	0	0	0	$1\frac{3}{4}$	$1\frac{7}{8}$	$24\frac{7}{16}$	$24\frac{7}{16}$	27	27		
	66%		$\frac{1}{8}$	$\frac{1}{8}$	$\frac{5}{32}+$	$\frac{5}{32}+$	$\frac{23}{32}$	$\frac{27}{32}$	$18\frac{7}{16}$	$18\frac{7}{16}$	$24\frac{3}{4}$	$24\frac{5}{8}$		
	50%	HALF STROKE	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{2}-$	$\frac{9}{16}$	$13\frac{7}{8}$	$14\frac{5}{8}$	23	23		
	33%		$\frac{1}{2}$	$\frac{1}{2}$	$\frac{7}{32}$	$\frac{7}{32}$	$\frac{5}{16}+$	$\frac{3}{8}$	$8\frac{3}{4}$	$9\frac{1}{4}$	$20\frac{1}{2}$	$20\frac{1}{4}$		
	25%	QUARTER STROKE	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{32}+$	$\frac{7}{32}+$	$\frac{9}{32}$	$\frac{5}{16}$	$6\frac{7}{8}$	$7\frac{3}{16}$	19	$18\frac{7}{8}$		
	20%		$1\frac{1}{8}$	$1\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}-$	$\frac{1}{4}+$	$5\frac{1}{8}$	$5\frac{3}{8}$	$17\frac{3}{8}$	$17\frac{3}{8}$		
BACKWARD MOTION		FULL GEAR	0	0	0	0	$1\frac{13}{16}$	$1\frac{7}{8}$	$24\frac{15}{16}$	$24\frac{1}{2}$	$27\frac{1}{8}$	27		
	50%	HALF STROKE	$\frac{1}{4}+$	$\frac{1}{4}+$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{15}{32}$	$\frac{9}{16}$	$13\frac{15}{16}$	$13\frac{7}{8}$	$23\frac{1}{8}$	$22\frac{1}{2}$		
	33%		$\frac{5}{8}$	$\frac{5}{8}$	$\frac{7}{32}-$	$\frac{7}{32}-$	$\frac{5}{16}$	$\frac{3}{8}$	$8\frac{1}{2}$	$9\frac{1}{8}$	$20\frac{1}{2}$	$19\frac{7}{8}$		
	25%	QUARTER STROKE	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{32}+$	$\frac{7}{32}+$	$\frac{9}{32}$	$\frac{11}{32}$	$6\frac{3}{8}$	$7\frac{7}{16}$	19	$18\frac{3}{4}$		

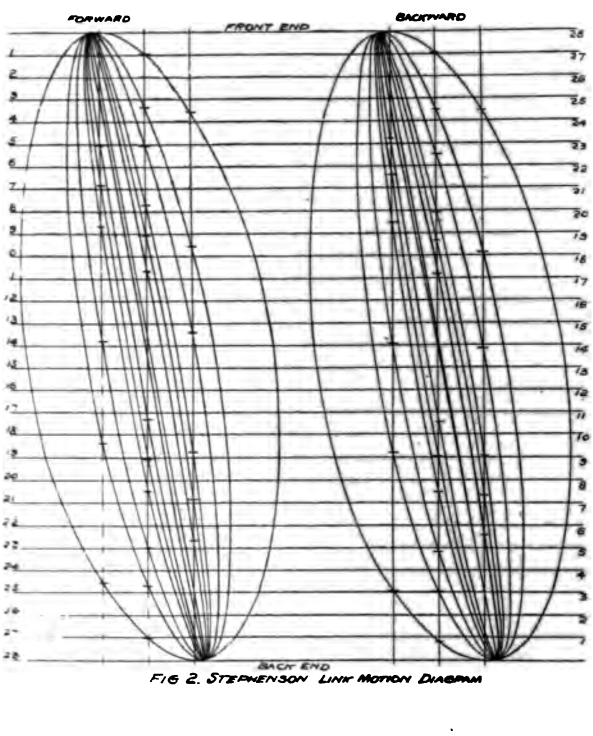


FIG 2. STEPHENSON LINK MOTION DIAGRAM

TABLE 3.

VALVE MOTION REPORT.—A. L. CO. ——— ORDER NO. 1114.—
BROOKS WORKS,— JANUARY 25, 1907. ATLANTIC TYPE PASSENGER ENGINE.
WALSCHAERT MOTION, 21" x 26" CYLINDERS, 78" DRIVERS.
VALVE TRAVEL $5\frac{3}{4}$", — STEAM LAP — 1", — LEAD CONSTANT — $\frac{1}{4}$".
——— SEE FIG. 3, VALVE MOTION DIAGRAM. ———

CUT OFF POSITION			PRE-ADMISSION		LEAD		PORT OPENING		CUT OFF		RELEASE		CLOSURE	
			FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK
FORWARD MOTION		FULL GEAR	0	0			$1\frac{13}{16}$	$1\frac{13}{16}$	$21\frac{3}{4}$	$21\frac{7}{8}$	$24\frac{9}{16}$	$24\frac{9}{16}$		
	66%		$\frac{3}{16}$	$\frac{3}{16}$			$\frac{27}{32}$	$\frac{27}{32}$	$17\frac{5}{8}$	$17\frac{7}{16}$	$22\frac{7}{8}$	$22\frac{13}{16}$		
	50%	HALF STROKE	$\frac{5}{16}$	$\frac{3}{8}$			$\frac{1}{2}$	$\frac{17}{32}$	14	$13\frac{3}{4}$	$21\frac{3}{8}$	$21\frac{3}{16}$		
	33%	-	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{1}{4}$"		$\frac{5}{16}$	$\frac{11}{32}$	$9\frac{3}{8}$	$9\frac{3}{8}$	$19\frac{1}{8}$	19		
	25%	QUARTER STROKE	$\frac{3}{4}$	$\frac{7}{8}$			$\frac{1}{4}$	$\frac{9}{32}$	$7\frac{1}{2}$	$7\frac{1}{2}$	18	$17\frac{15}{16}$		
	20%		1	$1\frac{1}{8}$			$\frac{7}{32}$	$\frac{1}{4}$	6	6	$16\frac{7}{8}$	$16\frac{3}{4}$		
BACKWARD MOTION		FULL GEAR	0	0			$1\frac{3}{4}$	$1\frac{7}{8}$	$22\frac{1}{4}$	$22\frac{1}{4}$	$24\frac{13}{16}$	$24\frac{5}{8}$		
	50%	HALF STROKE	$\frac{3}{8}$	$\frac{3}{8}$			$\frac{1}{2}$	$\frac{1}{2}$	13	$13\frac{7}{8}$	$21\frac{3}{16}$	$23\frac{1}{8}$		
	33%		$\frac{9}{16}$	$\frac{5}{8}$			$\frac{11}{32}$	$\frac{11}{32}$	9	$9\frac{5}{8}$	19	$19\frac{3}{8}$		
	25%	QUARTER STROKE	$\frac{7}{8}$	1			$\frac{1}{4}$	$\frac{1}{4}$	$6\frac{7}{8}$	7	$17\frac{1}{2}$	$17\frac{7}{8}$		

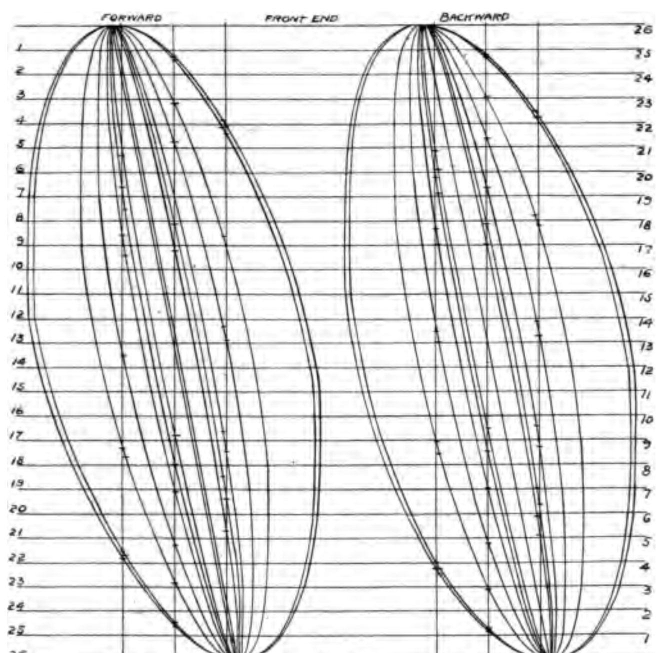


FIG. 3. WALSCHAERT VALVE MOTION DIAGRAM

TABLE 4.

VALVE MOTION REPORT. A. L. CO. ORDER. No. 5437.
BROOKS WORKS, FEBRUARY 27, 1907. 10 WHEEL PASSENGER ENGINE
WALSCHAERT MOTION, 21" x 26" CYLINDERS, 63" DRIVERS.
VALVE TRAVEL $5\frac{3}{4}$", STEAM LAP. 1", LEAD. CONSTANT $\frac{1}{4}$".
SEE FIG. 4. VALVE MOTION DIAGRAM.

CUT OFF POSITION			PRE-ADMISSION		LEAD		PORT OPENING		CUT OFF		RELEASE		CLOSURE	
			FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK
FORWARD MOTION		FULL GEAR	0	0			$1\frac{13}{16}$	$1\frac{15}{16}$	22	$22\frac{1}{8}$	$24\frac{5}{8}$	$24\frac{5}{8}$	$\frac{11}{16}$	$\frac{11}{16}$
	66%		$\frac{1}{16}$	$\frac{1}{16}$			$\frac{13}{16}$	$\frac{7}{8}$	$17\frac{3}{16}$	$17\frac{3}{16}$	$22\frac{5}{8}$	$22\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{11}{16}$
	50%	HALF STROKE	$\frac{3}{16}$	$\frac{3}{16}$			$\frac{1}{2}$	$\frac{17}{32}$	13	13	$20\frac{7}{8}$	$20\frac{3}{4}$	$2\frac{11}{16}$	$2\frac{9}{16}$
	33%		$\frac{7}{16}$	$\frac{3}{8}$			$\frac{5}{16}$	$\frac{11}{32}$	$8\frac{1}{2}$	$8\frac{1}{2}$	$18\frac{1}{2}$	$18\frac{7}{16}$	$3\frac{13}{16}$	$3\frac{3}{4}$
	25%	QUARTER STROKE	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{3}{16}$ LEAD		$\frac{1}{4}$+	$\frac{1}{4}$+	$6\frac{1}{8}$	$6\frac{1}{8}$	$16\frac{11}{16}$	$16\frac{11}{16}$	$4\frac{11}{16}$	$4\frac{11}{16}$
3	20%		$\frac{7}{8}$	$\frac{13}{16}$			$\frac{1}{4}$-	$\frac{1}{4}$-	$5\frac{3}{16}$	$5\frac{3}{16}$	$15\frac{7}{8}$	$15\frac{7}{8}$	$5\frac{1}{16}$	$5\frac{1}{16}$
BACKWARD MOTION		FULL GEAR	0	0			$1\frac{7}{8}$	$1\frac{7}{8}$	$22\frac{9}{16}$	$22\frac{3}{16}$	$24\frac{7}{8}$	$24\frac{5}{8}$	$\frac{11}{16}$	$\frac{19}{32}$
	50%	HALF STROKE	$\frac{3}{16}$	$\frac{3}{16}$			$\frac{1}{2}$	$\frac{17}{32}$	13	13	$21\frac{1}{8}$	$20\frac{15}{16}$	$2\frac{9}{16}$	$2\frac{7}{16}$
	33%		$\frac{7}{16}$	$\frac{3}{8}$			$\frac{5}{16}$	$\frac{5}{16}$+	$8\frac{1}{2}$	$8\frac{1}{2}$	$18\frac{3}{4}$	$18\frac{5}{8}$	$3\frac{3}{4}$	$3\frac{11}{16}$
	25%	QUARTER STROKE	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{16}$ LEAD		$\frac{1}{4}$+	$\frac{1}{4}$+	$6\frac{5}{16}$	$6\frac{5}{16}$	$17\frac{1}{8}$	$17\frac{1}{8}$	$4\frac{1}{2}$	$4\frac{7}{16}$

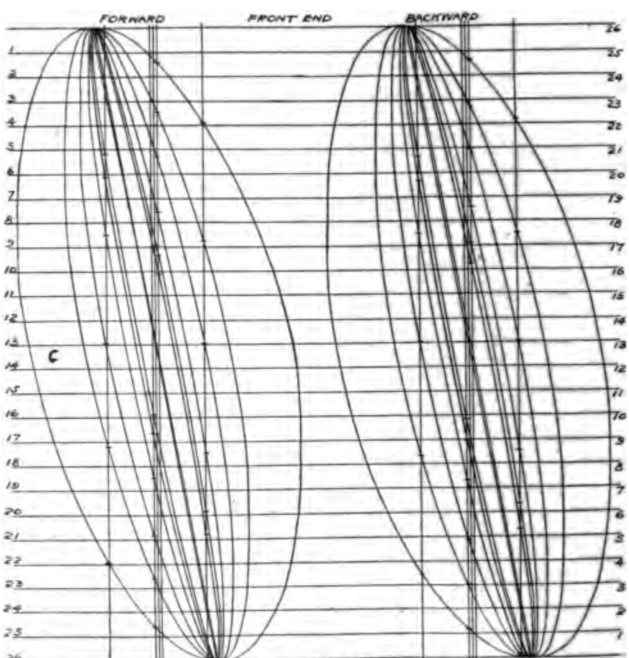


FIG. 4. WALSCHAERT VALVE MOTION DIAGRAM.

TABLE 5.

VALVE MOTION REPORT. A. L. CO. ORDER No. 1083.
BROOKS WORKS, JULY 12 1906. CONSOLIDATION FREIGHT ENGINE.
WALSCHAERT MOTION 19" x 28" CYLINDERS, 62" DRIVERS.
VALVE TRAVEL 5" STEAM LAP 1", LEAD CONSTANT $\frac{19}{64}$"
SEE FIG. 5 VALVE MOTION DIAGRAM

CUT OFF POSITION			PRE-ADMISSION		LEAD		PORT OPENING		CUT OFF		RELEASE		CLOSURE	
			FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK
FORWARD MOTION		FULL GEAR	0	0			$1\frac{17}{32}$	$1\frac{17}{32}$	$22\frac{3}{4}$	$22\frac{11}{16}$	$26\frac{3}{16}$	$26\frac{1}{8}$		
	66%		$\frac{3}{16}$	$\frac{3}{16}$			$\frac{7}{8}-$	$\frac{7}{8}-$	$18\frac{3}{4}$	$18\frac{9}{16}$	$24\frac{3}{4}$	$24\frac{5}{8}$		
	50%	HALF STROKE	$\frac{7}{16}$	$\frac{3}{8}$	CONSTANT		$\frac{17}{32}-$	$\frac{1}{2}+$	$13\frac{3}{4}$	$13\frac{7}{8}$	$22\frac{5}{8}$	$22\frac{9}{16}$		
	33%		$\frac{3}{4}$	$\frac{5}{8}$			$\frac{11}{32}-$	$\frac{11}{32}$	$8\frac{15}{16}$	$9\frac{1}{4}$	$20\frac{1}{16}$	$20\frac{1}{16}$		
	25%	QUARTER STROKE	1	1	$\frac{19}{64}$		$\frac{9}{32}+$	$\frac{9}{32}$	$6\frac{7}{8}$	$6\frac{15}{16}$	$18\frac{5}{8}$	$18\frac{9}{16}$		
	20%		$1\frac{3}{8}$	$1\frac{3}{8}$			$\frac{1}{4}+$	$\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{9}{16}$	$17\frac{1}{4}$	$17\frac{1}{4}$		
BACKWARD MOTION	—	FULL GEAR	0	0			$1\frac{15}{32}$	$1\frac{15}{32}$	$23\frac{1}{16}$	$22\frac{5}{8}$	$26\frac{3}{8}$	$26\frac{1}{8}$		
	50%	HALF STROKE	$\frac{7}{16}$	$\frac{3}{8}$	CONSTANT		$\frac{1}{2}+$	$\frac{1}{2}$	$13\frac{1}{2}$	$13\frac{5}{8}$	$22\frac{7}{8}$	$22\frac{7}{16}$		
	33%		$\frac{3}{4}$	$\frac{5}{8}$			$\frac{11}{32}$	$\frac{11}{32}$	$8\frac{7}{8}$	$9\frac{3}{16}$	$20\frac{1}{8}$	$20\frac{1}{8}$		
	25%	QUARTER STROKE	1	$\frac{7}{8}$	$\frac{19}{64}$		$\frac{9}{32}$	$\frac{9}{32}$	$6\frac{9}{16}$	$6\frac{7}{8}$	$18\frac{1}{2}$	$18\frac{3}{16}$		

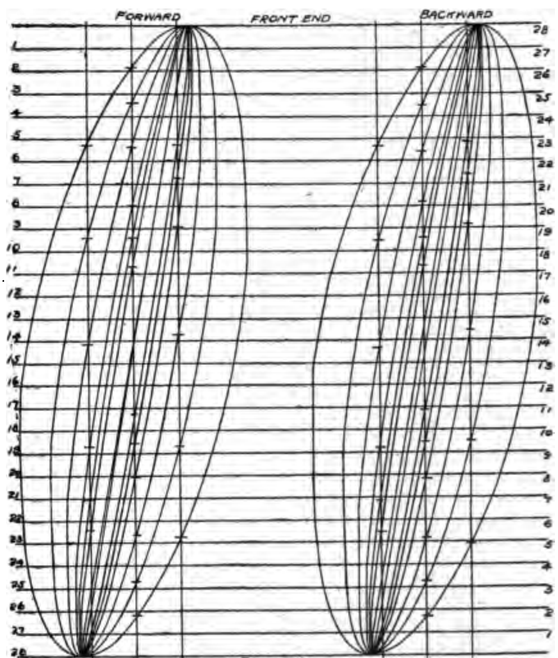


FIG. 5. WALSCHAERT VALVE MOTION DIAGRAM

TABLE 6

VALVE MOTION REPORT — A. L. CO. — ORDER NO. 1112.
BROOKS WORKS, JANUARY 24, 1907. CONSOLIDATION FREIGHT ENGINE.
WALSCHAERT MOTION, 23" x 32" CYLINDERS. 63" DRIVERS.
VALVE TRAVEL $5\frac{3}{4}$". STEAM LAP 1". LEAD CONSTANT $\frac{1}{4}$".
SEE FIG. 6. VALVE MOTION DIAGRAM.

Cut Off Position			Pre-Admission Front	Pre-Admission Back	Lead Front	Lead Back	Port Opening Front	Port Opening Back	Cut Off Front	Cut Off Back	Release Front	Release Back	Closure Front	Closure Back
Forward Motion		Full Gear	0	0	$\frac{1}{4}$" Constant		$1\frac{7}{8}$	$2\frac{1}{32}$	$25\frac{15}{16}$	$25\frac{9}{16}$	$28\frac{3}{4}$	$28\frac{7}{16}$		
	66%		$\frac{3}{16}$	$\frac{3}{16}$			$\frac{29}{32}$	$\frac{15}{16}$	$20\frac{5}{16}$	$20\frac{1}{16}$	$26\frac{5}{8}$	$26\frac{1}{4}$		
	50%	Half Stroke	$\frac{3}{8}$	$\frac{3}{8}$			$\frac{17}{32}$	$\frac{19}{32}$	$15\frac{7}{16}$	$15\frac{5}{16}$	$24\frac{9}{16}$	$24\frac{1}{8}$		
	33%		$\frac{11}{16}$	$\frac{7}{8}$			$\frac{11}{32}$	$\frac{3}{8}+$	$10\frac{3}{16}$	$10\frac{3}{16}$	$21\frac{11}{16}$	$21\frac{1}{4}$		
	25%	Quarter Stroke	1	$1\frac{1}{8}$			$\frac{9}{32}+$	$\frac{11}{32}-$	$7\frac{13}{16}$	$7\frac{13}{16}$	$20\frac{1}{8}$	$19\frac{13}{16}$		
	20%		$1\frac{7}{16}$	$1\frac{11}{16}$			$\frac{1}{4}+$	$\frac{9}{32}+$	$5\frac{7}{8}$	$5\frac{7}{8}$	$18\frac{7}{16}$	$18\frac{1}{4}$		
Backward Motion		Full Gear	0	0	$\frac{1}{4}$" Constant		$1\frac{7}{8}$	$1\frac{15}{16}$	$25\frac{3}{4}$	$25\frac{11}{16}$	$28\frac{1}{2}$	$28\frac{7}{16}$		
	50%	Half Stroke	$\frac{3}{8}$	$\frac{9}{16}$			$\frac{1}{2}+$	$\frac{9}{16}$	$14\frac{11}{16}$	$14\frac{11}{16}$	24	24		
	33%		$\frac{13}{16}$	1			$\frac{11}{32}$	$\frac{13}{32}$	$9\frac{9}{16}$	$9\frac{11}{16}$	$21\frac{1}{8}$	$21\frac{1}{8}$		
	25%	Quarter Stroke	$1\frac{5}{16}$	$1\frac{1}{2}$			$\frac{9}{32}$	$\frac{11}{32}$	$6\frac{11}{16}$	$6\frac{11}{16}$	$18\frac{7}{8}$	$18\frac{13}{16}$		

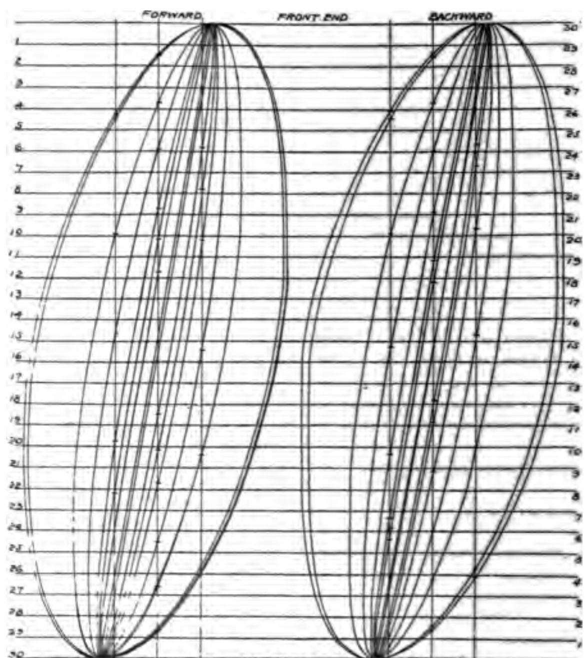


FIG 6 WALSCHAERT VALVE MOTION DIAGRAM

TABLE 7.

VALVE MOTION REPORT. A. L. CO. ORDER NO. 1115.
BROOKS WORKS, FEBRUARY 27, 1907. DECAPOD FREIGHT ENGINE
WALSCHAERT MOTION, 24" x 28" CYLINDERS, 52" DRIVERS.
VALVE TRAVEL $6\frac{1}{4}$", STEAM LAP 1", LEAD CONSTANT $\frac{3}{16}$"
SEE FIG. 7. VALVE MOTION DIAGRAM.

CUT OFF POSITION			PRE-ADMISSION		LEAD		PORT OPENING		CUT OFF		RELEASE		CLOSURE	
			FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK	FRONT	BACK
FORWARD MOTION		FULL GEAR	0	0	$\frac{3}{16}$" CONSTANT		$2\frac{1}{8}$	$2\frac{1}{8}$	$24\frac{5}{8}$	$24\frac{3}{8}$	$26\frac{15}{16}$	$26\frac{13}{16}$		
	66%		$\frac{1}{8}$	$\frac{1}{8}$			$\frac{7}{8}$	$\frac{7}{8}$	$18\frac{3}{4}$	$18\frac{1}{2}$	$24\frac{3}{4}$	$24\frac{5}{8}$		
	50%	HALF STROKE	$\frac{5}{16}$	$\frac{1}{4}$			$\frac{1}{2}$	$\frac{1}{2}+$	$13\frac{13}{16}$	$13\frac{13}{16}$	$22\frac{3}{4}$	$22\frac{3}{4}$		
	33%		$\frac{9}{16}$	$\frac{9}{16}$			$\frac{5}{16}$	$\frac{5}{16}$	9	9	$20\frac{3}{8}$	$20\frac{3}{8}$		
	25%	QUARTER STROKE	$\frac{13}{16}$	$\frac{13}{16}$			$\frac{9}{32}$	$\frac{9}{32}$	$6\frac{7}{8}$	$6\frac{7}{8}$	$18\frac{7}{8}$	$18\frac{7}{8}$		
	20%		$1\frac{1}{16}$	$1\frac{1}{16}$			$\frac{7}{32}$	$\frac{1}{4}$	$5\frac{5}{16}$	$5\frac{5}{16}$	$17\frac{5}{8}$	$17\frac{5}{8}$		
BACKWARD MOTION		FULL GEAR	0	0	$\frac{3}{16}$" CONSTANT		$2\frac{3}{16}$	$2\frac{1}{8}$	$24\frac{7}{8}$	$24\frac{11}{16}$	27	$26\frac{15}{16}$		
	50%	HALF STROKE	$\frac{1}{4}$	$\frac{1}{4}$			$\frac{1}{2}$	$\frac{17}{32}$	$13\frac{15}{16}$	$13\frac{13}{16}$	$23\frac{1}{16}$	$22\frac{7}{8}$		
	33%		$\frac{7}{16}$	$\frac{7}{16}$			$\frac{5}{16}$	$\frac{11}{32}$	$9\frac{1}{2}$	$9\frac{7}{16}$	$20\frac{15}{16}$	$20\frac{13}{16}$		
	25%	QUARTER STROKE	$\frac{11}{16}$	$\frac{11}{16}$			$\frac{7}{32}$	$\frac{1}{4}+$	$6\frac{13}{16}$	$6\frac{3}{4}$	19	$18\frac{15}{16}$		

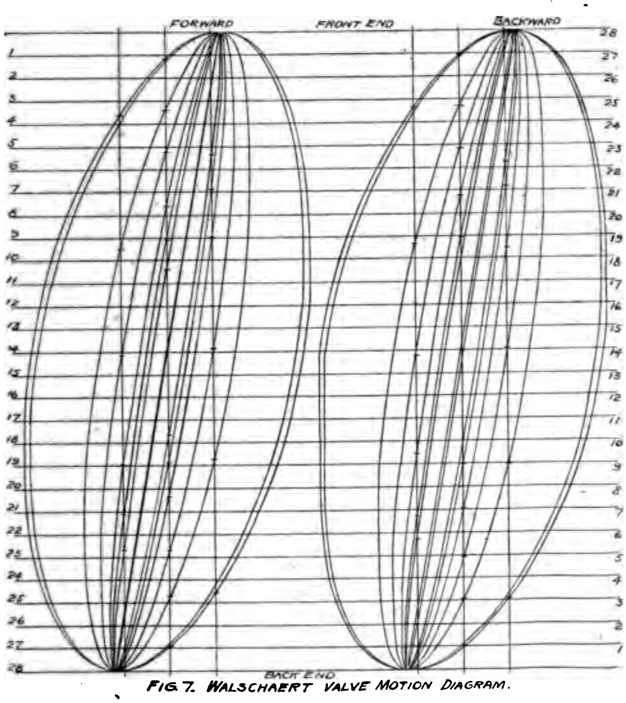


FIG. 7. WALSCHAERT VALVE MOTION DIAGRAM.

(14) We are also able to present some valve motion diag illustrate graphically the valve movements, and they are numbe Fig. 1 to Fig. 7 and refer to the same engines as Tables 1 to 7 diagrams are drawn by a machine similar in principle to that on page 292 of 1906 Proceedings, used in connection with a large complete valve motion model at the Brooks Works of the Americ motive Company.

(15) The Baldwin Locomotive Works has recently dev machine for the purpose, shown by cuts Figs. 8 and 9, and whic

FIG. 8.

FIG. 9.

quickly attached to an engine for the purpose of obtaining a val diagram. Used in this way, the results obtained should show effect of spring and of all lost motion in the valve-moving mech

(16) Two sets of diagrams drawn by this machine on simila except as to their valve motion, are shown in Fig. 10. Diagram also 7 and 4, are close comparisons of the valve operation by S and Walschaert motion respectively. Diagram 5, with 2.45 inc travel, gives about the same results as those shown in Diagram inches travel. These diagrams clearly show the fact, that, notwit the constant lead of the Walschaert motion, the preadmission favorable at short cut-offs than with the Stephenson motion. T

rams, together with the ones previously presented, are an interesting study ɔ the valve motion student.

(17) From this data it may be noted that the various points of pre-dmission, port openings, equalization of cut-offs, release and the closures an be as favorably arranged with Walschaert motion as with the link ıotion examples presented.

(18) The following tables of weights are given us for engines, said ɔ be identical in everything except the valve motion, and for a 22-inch onsolidation engine, built by the Baldwin Locomotive Works.

TABLE No. 8.

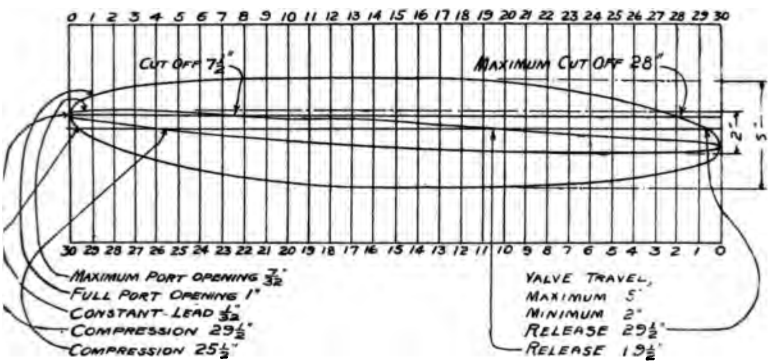
	COMPLETE MOVING AND STRUCTURAL PARTS.		MOVING PARTS ONLY.	
	Stephenson.	Walschaert.	Stephenson.	Walschaert.
rossheads	676	746	676	746
uide bearer	814	1,116	....	....
uides	1,712	1,712	....	....
ccentrics	600	....	600	....
rank arms	....	250	....	250
ccentric straps	1,100	....	1,100	....
Iain crank pins	520	516	520	516
inks	238	418	238	413
everse shaft	325	655	325	655
ockers and boxes	618	730	618	730
ocker rods and hangers	169	....	169	....
ink bearing	....	234	....	....
ccentric rods	184	264	184	264
alve rods	220	546	220	546
alve yokes	154	140	154	140
alve rod guide	24	28	....	....
Complete set	7,354	8,321	4,804	4,265

(19) These figures indicate that while the engine with Walschaert ıotion weighed 1,000 pounds more than the other one, account of the ıotion, yet the weight of the moving parts was less. The *American Engineer and Railroad Journal* of June, 1905, published some figures show-ıg saving of weight by the use of Walschaert motion on L. S. & M. S. ngines, as follows: 1,283 pounds on a consolidation, 1,215 pounds and ,745 pounds respectively on two classes of Prairie type engines. These gures indicate a larger saving than the foregoing example, but it is possi-le that as these were early developments, they may not be representative f present successful practice.

(20) It is a fact that similar valve motion parts on engines abroad ıre very much lighter than we dare use in our own practice. It seems fair

account of absence of preadmission, small amount of lead, quick port opening, large exhaust area and fine equalization of the events. It is claimed, due to these features, that fine performance and superior economies are obtained which more than compensate for the cost of maintenance of additional parts required.

(27) For the past six years, the Allfree-Hubbell designs for improving steam distribution have been under test and the designers have made



Cylinders 23 x 30.	Inside Clearance, Full Gear 0
Cylinder Clearance 4%	Inside Clearance, 25% Cut Off 3/16"
Steam Ports 1 x 35" 35 Square Inches.	Travel of Valve 5"
Exhaust Ports 2 x 17½" 35 Square Inches.	Lead 1/32" Constant
Outside Lap 5/8"	Pre-Admission 0.

	Cut Off, Front End.	Cut Off, Back End	Difference in Cut Off	Exhaust Opens, Front	Exhaust Opens, Back	Difference in Exhaust Openings	Exhaust Closes, Front	Exhaust Closes, Back.	Difference in Exhaust Closure	Maximum Port Opening.	Area of Port Opening	Area of Exhaust Opening	
Forward Motion	28"	28"	0	29½	29½"	0	29½"	29½"	0	1"	35	35	
	20"	20¼"	¼	27"	27½"	½	28¾"	28¼"	½	5/8"	21.9	35.	
	13"	13⅛"	⅛	24¼"	24¾"	¼	27"	27"	0	3/8"	13.1	35.	
	9½"	9½"	0	22½"	22¾"	¼	26¼"	26¼"	0	¼"	8.7	35	
	7½"	7½"	0	19"	19½"	½	25½"	25½"	0	7/32"	7.7	35	
	5½"	5½"	0	17½"	17¾"	¼	24½"	24½"	0	3/16"	6.6	35	
Back Motion	28"	28"	0	29½"	29½"	0	29½"	29½"	0	1"	35.	35	
	18"	18"	0	26⅞"	27"	⅛	28"	27⅞"	⅛	5/8"	21.9	35	
	13½"	13½"	0	24½"	24¾"	¼	27⅜"	27¼"	⅛	3/8"	13.1	35	
	8½"	8½"	0	20½"	20¾"	¼	26"	26"	0	¼"	8.7	35.	
	7"	7"	0	19"	19½"	½	25½"	25¼"	¼	3/16"	6.6	35	
	5"	5"	0	17"	17¼"	¼	24⅝"	24½"	⅛	5/32"	5.5	35.	

FIG. 11.

Young Valve Motion Diagram and Valve Events.

changes from time to time as to them seemed best. The first design or "geared system," as the designers called it, has been superseded by what is known as their "compression system," some of which have been in service for several months. This design is supposed to embrace the econo-

mic features of the original design with some additions, and, as it stands, it attempts to produce the following results: late release, late pression, low clearance, balanced compression, reduced cylinder radia quick admission and quick release.

(28) In the later design an auxiliary valve has been introduce the control of compression alone, and allows the main valves to be and set for a desired release with the Stephenson link, Walschaert, or other motion, all the changes being made in the cylinders and valve a

(29) This device has been under test on several roads and fror average of several reports it seems to give about six per cent redu in fuel consumption and five or six per cent increase in train load, ar able to maintain the same or a little more speed than engines of the size and ordinary design, except the cylinders. There is also a lig drain on the boiler for steam, but we are unable to express the amou figures.

(30) In making a study of this system for causes of the re claimed, we find a very late compression, which, according to the argu of the designers, means that the negative working pressure is acting time when it produces the least effect on crank pin. In other words, the crank pin is very near the center, from this point alone, an incre load is possible, not so much from an increased working pressure as a reduced negative work. In view of the above argument, any given could be handled with a less amount of steam, which means a less am of coal and therefore brings the handling of greater load within the p bilities of the boiler. In addition to this, the reduced clearance is clai to be responsible for a considerable steam economy.

(31) The following table of valve motion data has been furni by the courtesy of the designers of this motion and may be compared those presented earlier in this report. See Table No. 8 and Fig. 12.

Yours truly,

C. A. Seley (Chairman),
R. Quayle,
L. H. Turner,
J. H. Manning,
Committee.

Chicago, Ill., May 11, 1907.

The President: If there is no objection, the subject now be considered open for discussion. If any one has anyt to offer on this subject, we would like to hear from him, as time is becoming somewhat limited.

Mr. F. H. Clark (C. B. & Q. R. R.): I have had very experience with the Walschaert gear, and consequently car

little regarding its merits as compared with the Stephenson but I have been very much interested in reading the report e committee and admire the brief and concise way in which have set forth the advantages of the two principal valve . I think the committee should be commended for the man- n which the question has been handled.

[R. F. F. GAINES (C. of Ga. Ry.): I think this is a very y subject, inasmuch as for a great many reasons we have s looked very thoroughly into the question of valve gear. n instance why that is so, I would say that when we had nnual meeting of engineers recently, the subject of inspec- under engines came up. We had been publishing a report hich all defects not discovered by enginemen, but found by lhouse inspectors, were published weekly in a bulletin. The emen brought up the point that these inspections which had made by the roundhouse inspectors occurred at points where nginemen could not make an underside inspection, and they ed to be relieved from the responsibility for not reporting defects at places where there was no opportunity for them ake these underside inspections. We had to waive holding ngineers responsible for underside inspections at points where id not provide facilities for such inspections. It happened at a large percentage of our inspection points there were no ties for underside inspections. It becomes necessary to get id this by putting an outside valve gear on the locomotive e the engineers have a chance to get at it easily.

[R. E. A. MILLER (N. Y. C. & St. L.): Comparing failure alschaert valve-motion engines with the Stephenson link- on engines, our experience with fifteen engines with the henson and ten engines with the Walschaert used on the district and operated by the same men for four months, e engine failures of the Stephenson valve gear were reported mpared to one failure with the Walschaert valve gear.

[R. J. H. MANNING (D. & H. Co.): We have six large con- ation engines with Walschaert gear now in service, and have them in service for eleven months, and we have not done ents' worth of repairs, as far as putting in any pins or bush- or anything of that nature is concerned. We have twelve

Mr. E. A. Miller: I move that the report of the committee be received and the discussion closed. (Motion carried.)

The President: We will now take up the report of the Committee on Blanks for Reporting Work on Engines Undergoing Repairs, Mr. T. H. Curtis, chairman.

Mr. E. W. Pratt, a member of the committee, presented the report, which is as follows:

REPORT OF COMMITTEE ON BLANKS FOR REPORTING WORK ON ENGINES UNDERGOING REPAIRS.

To the Members:

Your committee appointed to recommend "Blanks for Reporting Work on Engines Undergoing Repairs" presumes that it was intended that this report should embrace blanks for reporting engines which are in service but need shopping, and blanks for reporting work done on engines which have undergone repairs, to be used as a permanent record. A report based on the literal reading of the subject assigned would seem of little value. We have also presumed that the report is to cover shop repairs and not running repairs.

Under the present method of making heavy or extensive repairs to engines at one or two main shops, and of making only light or running repairs at the small division shops or terminals, and of running engines out of terminals in either direction in pool service, and where Division Master Mechanics have no regular assignment of engines and, therefore, can not be held entirely responsible for the condition of engines on their respective divisions, the most important and essential feature in connection with the cost of "Repairs of Locomotives" and the results of operation is that of obtaining a correct and accurate report of the condition of engines in service, that they may be sent to the shops best equipped to do the class of repairs which they need, and that the condition of the engines on the various divisions may be kept consistent with the service required.

In order to assign engines to the shops intelligently, an accurate report of their condition and a comprehensive classification of the repairs required is necessary. Your committee does not believe that the "Classification of Locomotive Repairs" as recommended by the committee appointed on that subject, and which reported at the last convention, is best adapted for this purpose.

The operating officials in all departments are gradually adopting the use of the classification in vogue in the Motive Power Department on their respective roads, particularly with regard to engines in shop for repairs, and the classification should, therefore, be one that is free from complication and easily understood. In addition to the classification

recommended by the committee at the last convention being complicated, its costs considerable more to make repairs in some cases than in others, though the classification is the same. We believe the most practical and comprehensive classification is the Unit classification, based on the estimated cost of repairs, and have, therefore, used it in connection with the blanks recommended in this report. Under the Unit system engines requiring repairs estimated to cost $100 is termed class "1" repairs; $500, class "5" repairs; $800, class "8" repairs; $1,500, class "15" repairs; $3,000, class "30" repairs, etc. We also consider a more detailed report than the mere classification number (under any system of classification) is necessary in order to intelligently assign engines to the shops for repairs.

In order not to hold engines out of service awaiting room in the main shop, it can not be left to the discretion of division officials to forward engines to the main shop. They should be assigned to the shops by the head of the Mechanical Department, or one delegated by him to perform this duty. A record of the mileage made by each engine between shoppings and the repairs made to the engines at previous shoppings, as well as accurate reports of the condition of engines and a knowledge of the service required on each division, is essential to intelligently make shop assignments and secure the longest and best possible service at reasonable cost.

Your committee obtained from the heads of the Mechanical Departments of the principal roads forms in use for this purpose and, after a careful analysis of the subject and the forms submitted, recommend the use of the following blanks:

1 (Exhibit A). Blank showing condition in detail of engines which will require shopping within thirty days. This report is in duplicate form and that part pertaining to the condition of the engine is made by the Division Master Mechanic where the engine is in service and forwarded to the head of the Mechanical Department. The information relative to date, place and class of repairs, and mileage made since last shopping is inserted in the Superintendent of Motive Power's office, and if the shopping is approved the engine is ordered to such shop as best adapted to do the work required and at such time as it can be relieved and space can be assigned it in the shop. The original report will, at that time, be sent to the Master Mechanic or Superintendent of shop to which the engine is assigned for repairs, and the duplicate report filed in the office of the Superintendent of Motive Power as a permanent record. The Master Mechanic making the report should be held equally responsible with the Master Mechanic making the repairs for failure to report repairs needed to essential parts, if they are not made.

2 (Exhibits B and C). Blank (Exhibit B) is a weekly report to be made by each Master Mechanic to the head of the Mechanical Department, showing "Engines Turned Out of Shop," with date taken in, date turned out, and class of repairs made; "Engines in Shop," with date taken in,

date will probably be turned out, class of repairs, and, if waiting on material, the items, date and number of requisition upon which it is ordered; "Engines Out of Service, Waiting Repairs Account No Room In Shops," with date taken out of service, and class of repairs needed; "Available Track Room in Shop for More Engines," with number of additional engines that can be taken in shop.

From these reports a very concise statement (Exhibit C) can be compiled to be submitted to the heads of the Operating Department, but a printed form is not desirable for this statement as it can (on account of the varying number of engines in shop) be made on typewriter in more concise form.

3 (Exhibit D). Blank showing in detail repairs made to the various parts of engines, dates in and out of shop, mileage since last shopping, cost of repairs (with that due to collision and accident shown separately), and other general information which is of interest as a permanent record.

4 (Exhibit E). Blank showing in detail stay-bolt test and fire-box inspection and renewal of stay bolts. This blank is supplemental to blank Exhibit D, and is an essential record which can not practically be incorporated in blank Exhibit D.

5 (Exhibit F). Blank showing continuous shop record, mileage, cost of repairs of each individual engine. This is a permanent record for use in the Superintendent of Motive Power's office and the information is obtained from reports made on blanks Exhibit D, as furnished by the various Division Master Mechanics.

All of the foregoing blanks should be made of loose leaf form, that they may be bound in suitable binders. Blanks A, D, E and F should be bound with engine numbers in consecutive order and each fiscal year in separate volumes. Blanks C and D should be bound in order of date.

Many of the railroad companies submitted numerous blanks used by them in connection with shopping and repairs to engines, but we believe that a complicated system of numerous reports is expensive and undesirable and that the foregoing blanks are sufficient to furnish a practicable and permanent record of work done on engines undergoing repairs.

THEO. H. CURTIS (Chairman),
E. W. PRATT,
C. H. QUEREAU,
F. W. LANE,
Committee.

CHICAGO, ILL., May 3, 1907.

A. B. and C. RAILROAD COMPANY

Mr. ______________
Supt. of Motive Power.

______________ Division, ______________ 190

Engine No. ________ requires the following repairs and should be shopped during the next thirty days. Estimated class of repairs needed ______________

ENGINE PARTS	WORK REQUIRED
Boiler	
Fire Box	
Flues	
Frames	
Wheel Centers	
Axles, Driving	
Cylinders	
Crank Pins	
Driving Boxes	
Tires	

REMARKS.—(State other heavy work required not shown above.)

*LAST SHOPPED.—Date ______________ 190 Place ______________ Class repairs

Mileage made since last shopping ______________ miles.

SHOPPING APPROVED:

Supt. of Motive Power. ______________ Master Mechanic.

Ordered to ______________ Shops, Date ______________ 190.

______________ Supt. of Motive Power.

* Information regarding "last shopped" and mileage made will be inserted in Supt. of Motive Power's Office.

NOTE—Original of this report will be sent to the Master Mechanic of the Shop to which the engine is assigned when the assignment is made. Duplicate report will be filed in Superintendent of Motive Power's Office.

EXHIBIT "A."

FORM [illegible]—Revised [illegible]

A. B. AND C RAILROAD COMPANY

OFFICE OF MASTER MECHANIC.

REPORT OF ENGINES REPAIRED AND UNDERGOING AND WAITING REPAIRS.

__________ Shops, week ending __________ 190__

ENGINES TURNED OUT OF SHOPS

gine No.	Date Taken in	Date Turned out	Class of Repairs	REMARKS

ENGINES IN SHOPS

gine No.	Date Taken in	Date will Probably be Turned out	Class of Repairs	If Delayed Waiting Material, State Briefly what it is and Date and Number of Requisition on which Ordered

ENGINES OUT OF SERVICE, WAITING REPAIRS ACCOUNT OF NO ROOM IN SHOPS.

gine No.	Date Taken out of Service	Class of Repairs	REMARKS

If there are facilities and space in shop available for repairs to ines, state how many Engines could be accommodated if they d be spared from service.

____
MASTER MECHANIC

ASSIFICATION OF LOCOMOTIVE REPAIRS.

—Cost of Repairs —Class 1
— " " " — " 3
— " " " — " 7
— " " " — " 10
— " " " — " 15

EXHIBIT "B."

A, B AND C RAILROAD COMPANY.

ENGINES TAKEN IN SHOPS WEEK ENDING APRIL 27, 1907.

Engine No.	Date Taken In.	Date Will Probably Be Turned Out.	Class of Repairs.
......Shops.			
779	April 8	May 7	15
2061	April 8	May 17	18
341	April 20	May 20	18
......Shops.			
273	April 12	April 30	10
2023	March 23	April 30	20
539	April 20	April 30	15
1111	April 26	May 3	4
719	March 23	May 4	28
547	April 24	May 4	12
137	April 20	May 4	26
166	April 20	May 7	150
400	April 1	May 8	20
2012	April 27	May 10	15
920	April 23	May 11	23
31	April 15	May 11	18
887	March 23	May 11	33
343	April 9	May 11	20
768	April 26	May 14	15
724	April 25	May 15	18
918	April 3	May 18	40
604	April 20	May 20	35
806	April 15	May 20	40
......Shops.			
608	April 2	April 30	18
1049	April 22	May 1	2
607	March 26	May 7	21
266	April 8	May 7	16
503	April 20	May 9	18
764	April 12	May 16	19
959	April 23	May 20	17
......Shops.			
1088	April 21	April 27	1
332	April 11	April 30	3
453	April 25	May 3	1
361	March 23	May 4	10
129	April 15	May 15	7

Engine No.	Date Taken In.	Date Will Probably Be Turned Out.	Class of Repairs.
......Shops.			
754	April 26	April 30	1
446	March 14	May 4	12
201	April 24	May 4	3
642	April 10	May 10	12
......Shops.			
987	March 27	April 30	20
1068	April 10	April 30	7
718	March 30	May 2	18
153	April 22	May 4	5
1014	April 21	May 8	7
1055	April 21	May 11	7
924	April 4	May 15	22
1003	April 6	May 15	25
109	April 21	May 16	13
984	April 19	May 18	20
612	April 19	May 22	20
438	April 26	May 25	22
......Rd. House.			
262	April 22	April 24	1
1162	April 22	April 25	1
416	April 21	April 26	1
133	April 26	April 29	1
......Shops.			
58	April 24	April 26	2
329	April 19	April 29	5
123	April 5	May 1	8
330	April 24	May 4	5
529	April 24	May 6	5
1	April 5	May 20	20
......Shops.			
2072	April 26	April 29	1
119	April 21	April 30	2
......Shops.			
2020	April 22	May 2	6

ENGINES TURNED OUT OF SHOPS WEEK ENDING APR L 27 1907.

......Shops. 41, 225, 640.
......R. H. 262, 416, 1162.
......Shops. 116, 118, 627, 774, 879, 897, 1081.
......Shops. 704, 870, 930, 1031, 1062, 1067, 2032, 1145.

......Shops. **543, 900, 2059.**
......Shops. **442, 2014, 1088, 1089.**
......Shops. **68, 2105.**
......Shops. **605, 712, 713.**
......Shops. **960**

OFFICE OF SUPT. MOTIVE POWER,
........, April 29, 1907.

....
Supt. Motive Power

EXHIBIT "C."

At the conclusion of the report Mr. Pratt said:

I would say that this blank "D," which is the last in the report, can be used both for the report of actual work done and for the reporting by the Master Mechanic of the work which, in his estimation, should be done.

THE PRESIDENT: Gentlemen, this report is open for discussion.

MR. F. F. GAINES (C. of Ga. Ry.): The report embodies a number of very good forms, but there is one thing in connection with the report which I do not think has been fully covered. I know that it becomes very important at times to be able to give your operating officials a statement of how many engines you have available for service and how many engines you have in the shop daily, and that point does not seem to be covered particularly in the report. It could be handled in two ways — where the conditions are such that you can have the report made out and forwarded by train service every evening, and the information contained in the report tabulated at headquarters every morning; this method answers very well sometimes. In other cases it may be necessary to have a telegraphic report to cover this point. Generally speaking, it will be found that it is very desirable to find what engines have been shopped daily, those turned out and those put into the shop, for light repairs, and also a statement of those engines which are undergoing heavy repairs, so that the operating department can get some sort of concise statement showing just where it stands each day. Of course, this information will be equally of value to the shop department.

MR. H. EMERSON (A. T. & S. F. Ry.): I am very sorry that I had not seen this paper earlier, because it is one that I find exceedingly interesting. I have, however, this criticism to make of it, that it outlines admirable records of what is going on in the shop, but it does not seem to me to be worth anything at all in determining the policy of what is impending with reference to railroad affairs. Now, in looking over the repairs of a large railroad company we find that certain divisions suddenly go all to pieces. They are apparently in first-class condition, and inside of thirty days there is no motive power available — all the engines in the shop, virtually. That was the kind of thing we ran up against

n our road, so a method was devised that took the matter very ırgely out of the hands of the operating officials, as far as inforıation was concerned. Every single engine was put on an effiiency basis, in the same way that the men were put on an effiiency basis. The average of all the engines on the division had to verage 100. If they did not average 100, it was evident that the ngines were dropping backward, and we would soon find ourelves in a hole. If, on the other hand, the engines averaged more ıan 100, on the monthly average, we knew the conditions as to ıat division were satisfactory. In connection with that, the tonage by months for a series of years was plotted as to each parcular division, so that it was possible to say, without asking anyody whatever, exactly the period of the year when all the engines n any particular division would be required for very heavy serice, and also the particular time of the year when it would be onvenient to shop more engines from a particular division than t some other period.

Working along these lines, it has been possible to plot the efficiency of the engines at any moment, the efficiency of all the engines on the division, and plan months ahead as to just exactly how many engines should go into the shop and to tell the Master Mechanic three or four months ahead, "You must put so many engines into the shop next August, because if you do not put them in in August, you will be in trouble in September or October." This has introduced an entirely different method from the one vith which I was formerly acquainted for shopping and looking fter engines. I believe a paper on that subject by the men who ow have charge of that system would be an exceedingly interting one for this Association at some future time.

THE PRESIDENT: This is a very interesting subject, and we ould like to have further discussion if any of our members desire discuss the paper.

MR. F. F. GAINES: I move that the committee's report be cepted and that the committee be continued for another year d asked to investigate what is being done along the lines uched upon by the last speaker. (Motion carried.)

THE PRESIDENT: It is now 12 o'clock, but there is one subject n the program this morning which we must dispose of. I refer

to the report of the Committee on Development of Motor Cars for Light Passenger Service, of which Mr. H. F. Ball is chairman. The report is as follows:

REPORT OF COMMITTEE ON DEVELOPMENT OF MOTOR CARS FOR LIGHT PASSENGER SERVICE.

To the Members:

The paper presented on "Electricity on Steam Railroads" at the convention of 1906, devoted considerable attention to gasoline, gasoline-electric and steam rail motor cars, and showed the development of those types of cars up to that period. The advantages of the single motor car train unit were considered and discussed. There would appear, therefore, to be no need of considering that phase of the subject at this date, and this paper will deal simply with the development of the motor car in this country during the past year, and touch upon the situation as it exists abroad at this time.

GASOLINE MOTORS — MECHANICAL TRANSMISSIONS.

UNION PACIFIC.— In this country, the most extensive development work in the rail motor car field has been done by the Union Pacific Railway. To date, that railroad has built nine gasoline motor cars, all of which have direct mechanical drive.

Their latest design of car, Motor Car No. 8, is equipped with a 200 H.-P. motor, especially built for the rough service incident to that of suburban lines. The motor consists of six cylinders, 10 inches diameter by 12 inches stroke. The total weight of the car is 61,300 pounds, equivalent to practically 300 pounds weight per 1 H.-P. This car has, since last summer, been running regularly between Beatrice and Lincoln, Nebraska; it has shown remarkably uniform results and has materially increased the traffic between those two towns. Ten additional cars, similar to this successful model, are being built, as well as a number of trailers to be used in connection with them. Four regular branch line services have been maintained in Kansas and Nebraska, on the Union Pacific Railroad alone, during the severe weather conditions of the past winter, and with notable success. The motor cars have been remarkable in regularity of service, having demonstrated that they are even superior, in this respect, to the steam train service.

After two years of continuous service, it has been found that the average cost of fuel the year around, taking into consideration both summer and winter conditions, using 72 degree gasoline, amounts to 3.5 cents per car-mile. As a substitute for gasoline, California distillate has been used in regular service with gratifying results. Obviously, the cost per car-mile is thereby greatly reduced, as the distillate is a much cheaper

product than gasoline. Some interesting experiments have been conducted with the motor of Car No. 8, using denatured alcohol as fuel. The results were very satisfactory, in fact the newest type of motor (No. 8) gives equally as good performance with that fuel as with gasoline.

"SUNNY BROOK."— A light railway motor car, the "Sunny Brook," has recently been built at Indianapolis, Ind., for service in Yellowstone Park. This car has a four-cylinder gasoline motor, cylinders 6 by 6 inches, the engine developing 50 H.-P. at 700 R.P.M. The car is built after the conventional street car design and weighs 30,000 pounds. It is asserted that, at full speed, the car can attain thirty-five miles per hour. The transmission is of the mechanical type with three speeds forward and three reverse, with chain drive of the Renold silent chain type.

GASOLINE MOTORS — ELECTRIC TRANSMISSION.

STRANG CARS.— Another example of gasoline rail motor cars in successful operation is the Strang car, mentioned in last year's report. Three of these cars are in regular operation between Kansas City and Olathe. The first one has been in continuous service for over a year, the second and third cars having been in operation between six and seven months. Other cars of this type are now under construction for use on several steam roads. The transmission used in the Strang system is of the electric type, the generator being direct connected to the motor, forming a self-contained generating unit. Directly from the brushes of the generator, main wires lead to a controller of the series parallel type. From this controller, wires lead to electric motors hung on the axles of the front trucks according to standard electric railway practice. In multiple with the wires between the generator and controller, is connected a small storage battery, and in one of the main wires between the battery and the generator is placed a rheostat, which is used for the purpose of temporarily converting the generator into a motor when starting the engine. The first of the above-mentioned cars weighs 78,000 pounds, and it is claimed that the gasoline consumption has averaged about .45 of a gallon of gasoline per motor car-mile for a mileage of 60,000 miles. The largest and latest of the three cars above mentioned is 52 feet 9 inches long, weighs 84,000 pounds and has the following equipment: 100 H.-P. gasoline engine, 50 kw. generator, two 65 H.-P. motors and storage battery of 112 cells, with 250 A.H. capacity.

ST. JOSEPH VALLEY TRACTION COMPANY.— The motor car used on this road has been described a number of times in the technical press. It is of the gasoline-electric type and has been in actual daily service for two years. Within the past two months, the equipment was destroyed by fire. The service of this car consisted in hauling from one to three trailers, three round trips per day, over a road eleven and one-half miles in length, making the half trip in thirty-five minutes with four stops, the heaviest grade being one and one-half per cent. It is stated that the fuel consumption

with one trailer was three-fourths of a gallon per mile. The motor consisted of a four-cylinder, 70 H.-P. gas engine direct connected to a 50 kw., 250-volt generator in parallel with which was connected a battery. Four 50 H.-P. motors were used on the trucks. Weight of motor car 70,000 pounds; trailer 38,000 pounds. Very satisfactory service results are reported to have been obtained from this car.

General Electric Company Car.—This company is now bringing out its second-rail motor car of the gasoline-electric type. While the system used is the same in both cases, the second car is radically different in both design of car body and the power equipment, and promises to give very satisfactory results. The car body is of steel, the ends being rounded to decrease wind resistance. The roof is of the Mann type, equipped with globe suction ventilators. The car body is divided into an engine compartment, baggage, smoking, main and toilet compartments, and operating-cab at rear end. It has a seating capacity of forty.

The equipment consists of an eight-cylinder V construction gasoline motor of 150-175 H.-P., direct connected to an eight pole, commutating pole, 90 kw. generator with an exciter of 3½ kw. capacity, for the purpose of exciting the fields of the main generator, and effecting the variable potential control. From the generator leads are conducted to two 65 H.-P. motors, situated one upon each truck of the car. These motors are always connected in parallel, the required torque or speed being obtained by varying the field current of the generator through the intermediary of a specially constructed controller, embodying essentially the required resistance suitably arranged in fifteen steps.

The gasoline motor is of the four-cycle type, equipped with two separate systems of ignition; one, the high tension using induction coil connected to a four volt storage battery, the other make-and-break connected to a direct-driven Simms Bosch low tension magneto. The carbureter is of the single-nozzle hand-compensated type, gasoline being supplied to it by means of a diaphragm pump. Radiators for water cooling are located on the roof of the car. The circulation is by thermo syphon. The gasoline motor is controlled by one lever superimposed over the controller handle. The normal speed of motor is 550 R.P.M.

The car is heated by by-passing as much as required of the exhaust gases through pipes approximately in the same position as steam pipes in the standard railway coach.

An acceleration of a mile per hour per second is obtained to approximately 25 to 28 miles per hour. From this point, acceleration falls off gradually until full speed is attained at approximately 50 to 55 miles per hour. The total weight of the car is 60,000 pounds.

STEAM MOTORS.

Canadian Pacific.—In the steam motor car field, one of the noteworthy examples of original development work is found in the car designed and built by the Canadian Pacific Railway. This car was in operation at

of last summer between Montreal and Vaudreuil, a distance of twenty-four miles, giving a service of three round trips per day, on a regular schedule, allowing one hour for the run out, including twelve stops, and the same on the return trip. It was popular with the passengers and gave fairly good satisfaction to the railway company.

The boiler is of the return tube marine type, carrying 180 pounds pressure, equipped with superheater coils and a "Morrison" furnace, brick lined; crude oil is used as fuel with a burner of the "Booth" type having 1-inch slot.

The cylinders were originally turned out with bushes 10 by 15 inches, but after a time the bushes were removed, leaving the cylinders 11 by 15 inches. The valves, which are of the piston type, are fitted with "Walschaert" gear.

When the car was first put into service, 1.8 imperial gallons of oil were consumed per mile, but as the men gained experience in the handling of machinery, the consumption was reduced to 1.6 imperial gallons per mile; 5,000 gallons of water were evaporated per hour, giving a factor on one pound of oil to ten pounds of water.

Experiments have recently been made on the testing plant at the C. P. R. Shops with the same boiler and motor, using ordinary run of mine coal as fuel, instead of oil, with very satisfactory results, namely, during a test of one and a half hours, an average steam pressure of 172 pounds was maintained at a speed of 47½ miles per hour.

Total water evaporated, 8,569 pounds.
Water evaporated per hour, 5,720 pounds.
Total coal consumed, 1,300 pounds.
Pounds of water evaporated per pound of coal, 6.6.
Average temperature of gases in combustion chamber, 952° F.
Average temperature of steam at steam chest, 578° F.

GANZ CARS.— Motor cars of this type are being built for four different roads. All-steel construction is used for the body, which has a seating capacity for fifty-two passengers. Total weight of car in working order is 70,000 pounds.

The boiler or steam generator is of special design, carrying a working pressure of 270 pounds, the steam being superheated, capacity 120 H.-P. The steam motor is of the enclosed type with compound cylinders, all moving parts running in oil. It is mounted in the forward truck and drives the rear axle thereof through one set of gears.

This car is designed to maintain a speed of thirty-five miles per hour on a level track. Average fuel consumption is claimed to be from ten to twelve pounds coal per mile.

The development of motor cars abroad has made greater strides than in this country. Numerous English and Continental railway companies have permanently established rail motor car service in different localities with marked success. One may see such cars in operation on unimportant

branch lines as feeders to trunk line trains; on main lines through thickly populated districts carrying passengers to and from more important towns served by express trains; on suburban lines in competition with trolley cars and steam trains and on an entire railway system where there is no other means of transportation except for heavy freight.

A brief description of the motor cars in operation on the principal railways of England and the Continent is given herewith, which will serve to show the developments of this type of motor car abroad. It is not the purpose of this report to enter minutely into the details of construction, but rather to show up in a general way the present situation.

GASOLINE MOTORS — MECHANICAL TRANSMISSION.

GERMAN DAIMLER CAR.— The German Daimler gasoline car has been used in considerable numbers on some of the smaller German railways, notably the Wurtemburg State Railway and on the Swiss Federal Railway. It is a comparatively small car, having a total length of 33 feet, with a seating capacity of thirty-six. It is equipped with a 30 H.-P. Daimler engine of the heavy, slow-speed type, its normal speed being about 550 R.P.M. The motor has four cylinders 5¼ inches diameter by 6¾ inches stroke. It is located in the middle of the car, attached to a subframe upon which the car body is supported by eight elliptic springs, the subframe being carried rigid on the two axles. Power is transmitted from the motor through a leather-faced cone friction clutch, and through a sliding gear transmission (arranged to give four speeds and reverse) to one of the axles. Control levers are provided at each end of the car, by means of which the speed of the motor, or the direction of motion, is controlled from either platform.

GASOLINE MOTORS — ELECTRIC TRANSMISSION.

NORTH-EASTERN RAILWAY CAR.— About three years ago, the North-Eastern Railway of England put into service two "petrol-electric" cars. The power plant consists of a four-cylinder horizontal opposed Wolsey gasoline engine (8½ by 10 inches, 85 B. H.-P. at 420 R.P.M.) direct connected to a compound wound, separately excited generator, of 55 kw. capacity, which furnishes current to two 50 H.-P. electric motors, of the ordinary railway type, on the leading truck. The total weight, including 60 gallons of gasoline and about 100 gallons of cooling water, is 35 tons, of which 22 tons are carried on the power truck. These cars are used during the summer season only. Three and one-half car-miles per gallon of gasoline is claimed for them. As this particular type of car has not been perpetuated by the original builders and users, it is safe to assume that it is not entirely satisfactory. The enormous size and weight of the power plant and the space occupied (being about one-third the total length of the car), are undoubtedly the reasons for discontinuing the construction of this design.

ARAD & CSANADAR RAILWAY.— On the Arad & Csanadar Railway, in Hungary, a number of gasoline electric cars are used, the largest of which has a 70 H.-P. gasoline motor direct connected to a 45 kw. generator, which supplies current to ordinary railway type motors attached to the two axles. The usual series parallel controller is provided for starting. After the car is once under way, its speed is almost entirely controlled by the throttle of the gas engine. Controlling apparatus is provided at only one end of the car. The car is equipped with air and hand brakes, air being supplied by a small compressor driven from the outer end of the armature shaft. Jacket water from the motor is passed through coils inside the car for heating during cold weather. When no heat is required the water is passed through a coil of tubes on the roof. The space occupied by the power plant is considerably less in proportion to the length of the car than that of the North-Eastern Railway, although the systems are practically identical in principle. The acceleration of the car is very good. Its maximum speed is about thirty-five miles per hour without trailer. It is claimed by engineers of this road that sixty-five per cent of the motor's power is delivered at the wheels. Very satisfactory results are reported from these cars.

STEAM MOTORS.

GREAT WESTERN RAILWAY OF ENGLAND.— One of the most satisfactory cars in operation abroad at the present time is the one developed by the Chief Engineer of the Great Western Railway of England. In the neighborhood of sixty of these cars are in service on various parts of the Great Western System, and others are in course of construction. They combine to a remarkable degree many of those qualities essential to success, namely, large seating capacity with only moderate weight, flexibility of control, reasonable speed and acceleration, reliability, low maintenance and fair operating costs.

The boiler is of the vertical, fire-tube type with no superheater, supported directly on the frame of the power truck and serving as a center pin by transmitting the driving effort to the sills of the car through flat springs. It is enclosed within a compartment of the car body (about 14 feet long), which contains coal bunkers, operating levers, etc. As the car is arranged to run in both directions and controlled from both ends, a stoker is employed in addition to the driver. Aside from attending to the fire, it is his duty to regulate the cut-off when the driver is at the other end of the car, as only brake and throttle connections are provided there.

The motor consists of two single-expansion cylinders, 12 by 16 inches, coupled direct to the rear driving wheels, which in turn are coupled to the front drivers. Walschaert valve gear is used. The water supply is carried in tanks hung beneath the car body midway between the trucks. The cars are equipped with brakes. A maximum speed of fifty-five miles per hour can be obtained, although the average running speed is from thirty

to thirty-five miles per hour. Their maximum acceleration is about one mile per hour per second.

TAFF-VALE RAILWAY.— The Taff-Vale Railway has built a number of cars for its own use and for other railways, being similar in design to the Great Western car, the chief difference being in the construction of the boiler. This is of the fire-tube type and consists practically of two horizontal barrels placed on either side of a central furnace, the hot gases passing horizontally through the fire tubes to smoke box at the outer ends, and from there through the flues to a central stack. The boiler is placed transversely with reference to the car body and rests directly upon the truck frame back of the forward axle, which is the driving axle. The forward end of the car body is pivoted on the power truck, but does not include a compartment for boiler equipment as in the case of the Great Western. The power truck is self-contained and a cab is provided for the driver similar to that of a small locomotive. The cylinders are placed outside and the valves operated by an ordinary link motion with rocking shaft. This car is capable of running thirty-five miles per hour on the level and will ascend a 2½ per cent grade at twenty miles per hour. It can be operated from either end, and all operation, except starting, performed from the guard's compartment. The following data show the general dimensions of the car and power truck.

Latest type of Taff-Vale car:
- Over all, length, about 70 feet.
- Seating capacity, 43.
- Total weight, 42 tons.
- Weight on power truck, 30 tons.
- Cylinders: bore 10½ inches, stroke 14 inches.
- Total heating surface of boiler, 465 square feet.
- Grate area, 10 square feet.
- Capacity of water tank, 550 gallons.
- Steam pressure, 180 pounds.
- Tractive force, 5,292 pounds.
- Boiler has 232 1⅝-inch tubes.

LANCASHIRE & YORKSHIRE RAILWAY.— The Lancashire & Yorkshire Railway has cars similar to the Taff-Vale, in that the forward end is pivoted on the power truck. The boiler is of the usual locomotive type with horizontal fire tubes. This engine is practically a small locomotive with drivers coupled. The following gives the principal engine and boiler dimensions:

Heating surface:

199 fire tubes, 1¾-inch O.D., area	455 square feet.
Fire box area	54 square feet.
Total	509 square feet.
Grate area	9.4 square feet.
Water capacity	550 gallons.

Boiler pressure ....180 pounds.
Coal .... 1 ton.
Two cylinders, bore 12 inches, stroke 16 inches.

GANZ SYSTEM.— Ganz cars are used rather extensively in Central Europe in three sizes, 35, 50 and 80 H.-P. at 260 R.P.M. The general arrangement is the same in all three, the boiler being placed in a compartment at the forward end of the car, together with fuel bunker, feed pumps and controlling apparatus. The motor is placed horizontally on the leading truck, and drives the rear axle through spur gears. It is supported in the usual electric railway motor style, one end being swiveled above the axle, and the other supported elastically from the truck frame. The car is controlled from only one end and one man is required to operate it. The boiler consists of four concentric cylinders with headers (held in place by bolts) forming two annular water spaces joined together by means of slightly inclined steel water tubes, 25 mm. outside diameter and 2 mm. thick. Within the inner cylinder is another cylinder of slightly smaller diameter through which the fuel is fed to the grate below, the flame and hot gases passing around the water tubes to the stack. The motors are two-cylinder cross compound. The largest car, 80 H.-P., weighs 23 tons, and is capable of climbing 1.6 per cent grade, with two trailers weighing 12 tons each, at a speed of twenty-five miles per hour.

PURREY SYSTEM.— The Paris-Orleans road has ten cars and twelve power trucks equipped with the Purrey System. This system has also been used for a number of years on different tramway lines in the city of Paris.

The Paris-Orleans cars have a total length of about 60 feet with a capacity of thirty third-class passengers in three compartments, and twenty-five first-class passengers in two and one-half compartments, and in addition there is a baggage compartment at the forward end 11 feet 6 inches long. The forward end is pivoted on the power truck, the rear end being carried upon a single axle. The total weight of this car is about 35 tons. The power truck which carries the boiler, motor, fuel, water, etc., has a 126-inch wheel base, the rear wheels only being used for driving. The Purrey boiler is tubular, consisting of two drums, the lower one of rectangular section and made of cast steel, the upper one cylindrical and of cast iron. The lower drum is divided into three compartments, two of which are provided for water, the third being for superheated steam. The outer and lower compartment is connected with the upper drum by two large return pipes. It is also connected with the intermediate compartment of the same drum by 41 U-shaped tubes. The feed-water entering the lower compartment is thus heated in passing through these tubes, which are in direct contact with the flame. From this point the water rises through a series of U-shaped tubes to the upper drum, and the steam thus formed is returned from the upper drum through a number of similar tubes to the third compartment of the lower drum, from which

it is taken to the motor. The steam is highly superheated in these tub the average temperature of superheat being from 750° to 900° F. Cc is used for fuel, feeding automatically from a bunker attached to 1 side of the boiler, the supply being regulated by a vertical sliding do The motor is a four-cylinder tandem compound, rated at 260 H.-P. at (R.P.M. Ordinary D-type valves are used, operated through Stephen link motion. In this design the motor is attached horizontally to the fra of the car and its power transmitted to the rear axle by two tootl chains of similar construction to the Renold and Morse silent type. A rule, one or two trailers are attached to these cars, the average weight the train being 50 tons. The fuel consumption of this train is about pounds of coke per mile. The car is capable of maintaining a speed about fifty-six miles per hour. The cost of operation per train-mile about 7 cents.

SERPOLLET SYSTEM.—The Serpollet system differs from the Purrey Ganz types chiefly in that the boiler is of the flash type, and kerosene generally used as fuel. A very high degree of superheat is obtai (reaching even 1,200° F.), which, together with the incrustation attend the use of more or less impure water, is conducive to the burning of tul The experience of the Paris, Lyons & Mediterranean Ry. with this type car has been rather unsatisfactory, because of tube troubles, and the Pur car is now being adopted in its place.

KOMAREK CAR.—This car is used to some extent by the Austr State Railway and several of its branches. It is manufactured by F. Komarek in Vienna. Although built in several sizes and many forms, following type may be considered as a representative:

Car body, total length, 51 feet.
Seating capacity, 35.
Baggage-room, 44 by 96 inches.
Length of boiler and fuel compartment, 10 feet.
Weight, empty, 20 tons.
Coal capacity, 1,100 pounds.
Water capacity, 420 gallons.
Motor, 2-cylinder cross-compound, outside cylinders.
Cylinders, diameter, 10 by 15 inches, stroke 16 inches.

This car is capable of running at a speed of 25 miles per hour o level while hauling trailers comprising a total of 50 tons. The operat cost is said to be about 5 cents per train-mile (exclusive of the gua pay) coal costing $3.25 per ton, made up as follows:

Coal	$0.0253
Oil	.0014
Labor	.0046
Maintenance:	
Material	.0011
Driver	.016
	$0.0484

The motor car of the Intercolonial Railway of Canada is equipped with a steam motor similar in design to that of the Great Western Railway of England. This car has a total length of 66 feet, with a seating capacity of fifty-two passengers. The engine cylinders are 12 by 16-inch stroke, and the speed on one per cent grade is twenty-five miles per hour.

The information shown in the report pertaining to rail motor cars in England and the Continent was obtained by your committee from the chief engineer of the American Locomotive Automobile Company, who made a personal investigation of the subject abroad during the winter months of the past year.

THE PRESIDENT: The subject is open for discussion. The paper, when published in our Proceedings, will be accompanied with the cuts which Mr. Ball has, and which contain a great deal of valuable information for reference purposes.

MR. WILLIAM FORSYTH (*Railway Age*): I would like to supplement a portion of the remarks made by Mr. Ball, referring to the representative of the American Locomotive Works. He read a paper on the subject before the American Society of Mechanical Engineers at the Indianapolis meeting last month, and the special value of that paper is that it illustrated quite a number of the foreign boilers which are very interesting, and I think if any of the members want to follow this subject further, and see the details of the foreign boilers, they can obtain the paper from the secretary of the American Society of Mechanical Engineers.

MR. BALL: I will say in that connection that the Secretary now has the diagrams of these boilers, and it was the intention to put them into this paper, but they were received too late and will appear in the Proceedings.

MR. E. A. MILLER: I move that the paper be accepted and the committee discharged. (Carried.)

THE PRESIDENT: We now come to the subject carried over from yesterday.

THE SECRETARY: I will say that the Executive Committee approves of the placing of Mr. G. S. Allen, a Master Mechanic of the Philadelphia & Reading Railroad, and a member of this Asso-

ciation since 1892, a man who has been in the railroad service for fifty-two years, who has retired and is not now engaged in active work, on the honorary membership list.

Mr. F. F. Gaines: I move that the recommendation of the Executive Committee be approved and made effective. (Motion carried.)

The President: Gentlemen, as you will recall, at the time of adjournment yesterday we were discussing the paper by Mr. C. W. Cross on Apprenticeship System on the New York Central Lines. It was moved and carried yesterday that the discussion be taken up again to-day at the noon hour. We will now resume the discussion of that paper. The Secretary has a written discussion by Professor Goss, and I am sure you will all be interested in hearing it.

The Secretary read the following discussion:

Prof. W. F. M. Goss (Purdue University): Mr. President, no more important matter awaits the attention of the management of American railways than that of training men for its service. For years past large sums of money have been spent in the improvement of tracks, in perfecting equipments and in the elaboration of problems involved by the operation of trains. But the effectiveness of these improvements in material things must in the long run depend upon the degree of intelligence which controls their use. If the training of men has kept pace with the increased complication and higher efficiency of the material equipment employed, there will be no lack; otherwise there will be a condition of unbalance as of a refined instrument in hands insufficiently trained to guide it. It takes time to improve an organization. In the matter of training men it is less a question of to-day's efficiency than it is a matter of to-day's preparation for results which must be forthcoming to-morrow. This fact gives increased significance to the apprenticeship system of the New York Central Lines as outlined by Mr. Cross. The benefit can not be immediate — it looks to the future. The plan which has been adopted is, I think, admirable. By beginning with the apprentice boys, it starts right, and by giving systematic attention to the intellectual development of the apprentices, it proceeds along correct lines. I have no hesitation in saying that the railroad company project-

ing this system will receive large returns upon its investment; and I must add that the adoption of such a system well reflects the broad and progressive spirit which so often characterizes the acts of our worthy President, the General Superintendent of Motive Power and Machinery of the New York Central Lines.

As one from the college, I can not refrain from calling attention in this connection to a lack of interest on the part of American railways in men from the college. In making this statement I freely admit that the time has passed when a college diploma could be accepted as evidence of ability. Not all college men are intellectual giants, but the fact remains that among the graduates of our colleges are men who have good physique and sound minds, men who are able and willing to work, whose purposes are strong and whose characters are fine. The manufacturing interests of our country recognize this fact. Each year in March or April representatives of many of these establishments visit the colleges in their search for men whom they can start at the bottom of their organizations. In the exercise of their choice they are painstaking and discriminating. Notice is given of their coming, they gain acquaintance with a considerable number of prospective candidates, they examine, they cast out and finally select those who in their opinion give greatest promise of usefulness in their particular service. These manufacturing industries are not all large, but all are intent upon getting good material with which to supply the lower grades of their service. Of course, they are not always successful in getting their first choice, but they often succeed and the process is one which in the long run must win.

These manufacturing industries are not more important to the welfare of our country than the great railway corporations. They probably have no greater need of young men of superior quality than have the railroads. Nevertheless, it is my observation that railway companies do not ordinarily show an equal interest in recruiting their staff. When men are taken, selection is generally less made, and the number taken is comparatively small. Even the larger roads, which are by no means small, allow some years to pass in which they take no recruits from the colleges at all. I emphasize this matter because I think the intellectual training of apprentices and the practical training of college men are but dif-

ferent parts of the same problem and must eventually be developed together. The special apprentice courses for college graduates represent a step which a number of our larger lines have already taken and the plan which is now formulated by the New York Central Lines in the formation of a well-conceived system for schooling apprentices is a coördinate and equally important step. I look for large developments in both directions.

MR. W. B. RUSSELL (N. Y. C. Lines): It was predicted before we started this plan that the apprentice system would not last three months, and it probably would have failed, at least on the educational side, if the ordinary methods of instruction had been followed. The apprentice, as we find him, is not a man who can appreciate college methods, or any adaptation of college methods to his case. High school training will not fit him. It has been necessary to start fresh from the beginning, and develop a system of training to fit the special need we have here in America. German methods will not fit our American apprentices. It is a peculiar proposition and must be treated specially.

The two features of the work are the drawing courses and what are called the problem courses. Drawing courses for apprentices are nothing new, but our method of teaching drawing is different from anything I know of in this country. The geometrical work, which ordinarily takes a year or two in most evening schools, is omitted entirely. The boy starts immediately on practical work, being called upon to deal with actual conditions. The geometrical knowledge may be necessary, but that is introduced as it is wanted. We do not teach the principle and then apply it, but teach the application and the principle at the same time, the idea being to keep in view at all times the practical result to be gained. In our public school systems we have forgotten a great many points that must be considered in apprentice classes. This work must go much slower than ordinary school courses. The apprentice does not appreciate a lecture; it is wasted. The work must be individual; no system of teaching which requires the same standard from each apprentice will fill the bill. The quantity of ground to be covered is not an element in this. All of our public schools and high schools are intended to train for college, the high schools especially teach with that end

in view, and our public school training has drifted into that line. In the case of the work we are doing we have no college requirements to meet. What we are trying to make in this instance are men, and the best method does not consist in the quantity of work they cover, but in how they cover it.

With the apprentice no class work can be undertaken, because the classes, which are limited to twenty-four, may contain a boy just starting as an apprentice and another about to finish. By means of blue-print sketches it is possible for one instructor to keep each boy in the class on a different problem. These sketches give the apprentice full instructions as to what he is to do and how he is to do it, saving the instructor from the necessity of repeating details to each boy. The instructor is present to oversee the work. If the work was being carried out in a single shop, where the mechanical engineers and officers could father it and watch over it, many things could be done which it is impossible to do with schools widely scattered. Our schools are so located that it is impossible in some instances to visit them oftener than once a month. Nevertheless under these conditions the educational features work out successfully.

The second part of the work, the problem work, is unique in this respect — that we have nothing to fall back upon. As a matter of fact, we had to leave out everything in the text-books and have found it impossible to use them. There is nothing in the country at the present time to fit the needs of the apprentice, and it has been necessary to start from the beginning.

The practical problem is first stated and solved, then followed by a sufficient number of similar problems to cause the principle to take root. In everyday life we do not have a classification of arithmetic, geometry, etc., but the problems are a combination of these subjects. It would be impossible, however, to take problems directly from the shop as they come up and give them to the apprentices, but it is possible to select problems that will slowly increase in difficulty and thus use actual shop problems in instructing apprentices. In doing this there is no subdivision into arithmetic and algebra. If the problem requires algebra for its solution, the necessary amount is introduced, but without the apprentice knowing it. At one of the points the boys found that

they were working problems similar to those in the fourth year of the high school and the result of the discovery was that they became frightened and did not do the work so well.

Our aim in connection with these problems is to make them fit in as closely as possible with the boys' daily work. We get the problems from the instructors and mechanics and pick them up wherever we can, using all the illustrations possible from the actual road conditions, taking the data of a problem from the local division of a road, if possible.

I want to emphasize the matter of the personal touch between the apprentices and the instructor and between the instructors and the heads of the apprentice department. This statement may sound queer from the educational standpoint, but it has been clearly demonstrated that the personality of an instructor amounts to much more than his actual knowledge. The personal touch is the key to the situation. If the instructor does not know his pupil well enough so that the pupil will interrupt him in order to ask a question — if the relations between the instructor and the apprentice is not on such a footing that they feel at liberty to do this — he is not a good instructor. In many cases instructors are called by their first name by the apprentices, which shows how closely they work together. Many of our best instructors find it necessary to study at night in order to keep ahead of their classes. They make the best instructors because they can look at a subject from the apprentices' standpoint and can bring the apprentice up step by step, appreciating all of the difficulties because of the fact that they are studying themselves.

Referring to Professor Hibbard's remarks, the State can not undertake the whole of this educational work, it is true that our public school system is not preparing the right kind of men for apprentices. It is more and more evident that even high school graduates who come to us are deficient in many respects. In public school work it would be impossible to pick illustrations to suit in a single class all of the trades which the school should fit for. This is noticeable in evening classes, where the same class may contain a marine engineer, a locomotive engineer, a stationary engineer, a hardware clerk and possibly a clerk from a dry-goods store.

In regard to the college faculty and the advantages to be attained there, we have somewhat similar conditions in the fact of instructors visiting other schools, and it is arranged that at least once a year they will come together at one point. Shop visits are arranged for, and occasionally three or four instructors meet at one place to compare notes. The rivalry between the schools is very apparent and results in much good.

In regard to an understudy: We have now at most shops a man ready to step in and take the instructor's place. Since starting we have had at two schools three different instructors, and yet the work has gone on smoothly. What at first promised to be our greatest difficulty — the securing of instructors — has proved to be an easy matter. We have no dearth of instructors, are rapidly educating our own and already have a number of men at various shops who are thoroughly qualified. In this connection the mechanical engineer's department is coöperating by selecting only such men for shop draftsmen as will be capable in time of making good instructors. At each point on the system there is at least one apprentice who can take full charge of the class for one or two weeks and in one instance a shop instructor carried the entire educational work for a month while the regular instructor was ill. This was possible because of the arrangement of the work.

We are endeavoring as rapidly as possible to bring in experimental work, not the kind the colleges have, because we are not trying to prove the laws of nature, but the kind that will demonstrate and show the reason for things. We have introduced at most points a small engine, because we have found many apprentices did not know what a valve was, nor understood the definition of lap and lead. It is not too much to predict that every machinist in our class will be able to set valves before he graduates.

It was stated that this plan would not work where piece work was inaugurated. It will work equally well with either piece work or day work. We have it on both plans. Specialization and not piece work is to blame for the present lack of apprentices. This plan will also work in a small shop, and we expect to put it in shops where there are only five apprentices. It may be in this case that the shop instructor and the educational instructor will

be one and the same man and will give only a small portion of his time to the apprentice work.

Provision is made in the apprenticeship regulations for allowance to be made for previous experience, and that covers the college man. We have no objection to his taking our regular apprenticeship course. Allowance in time and rate of pay can be made with the assent of the superintendent of apprentices, so that it is an individual matter.

The system was started so gradually that the question of enthusiasm was not a factor. There is more enthusiasm now than there was a year ago. We had a letter the other day from one school saying there were twelve boys who were out of problems, and it was up to us to supply them — that shows the enthusiasm. The statement was made yesterday that we were supplying leaders rather than mechanics. If Mr. Setchel could see some of our apprentices, for example, in the foundry and boiler shop, he would realize that some of them at least would never become leaders. It has been said that the majority of men in a railroad shop must of a necessity be " hewers of wood and drawers of water," and it is this class that we are educating not out of the trade, but in the trade. We aim to reach the rank and file — the geniuses will take advantage of the conditions created and take care of themselves. The educational courses are not designed for high school graduates, but for the average apprentice, as we find him, frequently a young man who can not tell how many sixteenths there are in an inch, but who may develop into a good workman in the shop. It is true that we are supplying draftsmen for some parts of our road, but this is a part of our plan, as when we find a man adapted for the drafting room, it is to his interest and the company's interest to place him there.

PROF. H. WADE HIBBARD: In the absence of any one from the Pennsylvania Railroad being in the room just at the moment, I beg to read a half page from a recent number of the *Engineering Magazine,* in connection with an article entitled " A Railroad University: Altoona and Its Methods." " During the latter days of February, 1907, the city of Altoona added to its educational facilities a railroad high school which is the first institution of its kind in the United States. Its progress may mark the beginning

of a new era in education, if other industrial corporations see the advantages of forming such a working partnership with the public schools as the Pennsylvania Railroad has made in Altoona. The industrial department of this high school is fully equipped and all bills are paid by the railroad company. The department has nothing in common with manual training. A four-years' course is planned, beginning with mechanical drawing and ending with machine design. The creation of the department is the result of a desire on the part of the railroad to discover a way to combine its needs for trained employees with the aim of the public school authorities to turn out young men ready to earn a living.

"A drawing room, carpenter shop, forging room, a wood and metal working machinery department — all equipped with modern tools — together with the expert instruction to be provided, will enable the school to give students advantages heretofore enjoyed only by pupils of the best technical colleges.

"Graduates of the Altoona high school will be fitted to go directly into the Pennsylvania shops on a footing between the regular apprentices, who, as a rule, entirely lack training, and the more mature apprentices who are graduates of technical colleges. The railroad's return on its investment is expected in the way of better educated employees."

I saw in this morning's paper, what pleased me very much, as showing the publicity that has already been given to the discussion of yesterday, an account of the debate on this subject in the Philadelphia paper, mentioning what I endeavored to say yesterday and construing it as an arraignment of the lack of educational facilities in the public school system of the United States. I am very much pleased that so much publicity has been given to this matter. Of course, none of us are ignorant of the fact that there are manual training public schools here and there, but I feel that what education needs in this country is a widespread adoption of an educational system which shall be along the lines, perhaps, of this Altoona railroad high school. Mr. Russell just said that it would be impossible to do this sort of teaching in the public schools, and mentioned the necessity of individual problems differing from each other. I would like to say for his benefit, a[illegible] yours, too, that even in the large technical colleges, and I kn[illegible]

because I am doing just that sort of thing in my particular work, that in the case of the senior students I give each man an individual problem, and I have a whole group of men working at the same time in my drawing-room, and each man is working on a different problem, graded to suit the different men, and I do not expect every man to handle things in just the same way; but what I am after is, that each man shall progress in his ability to handle an engineering problem, and if one man progresses with one kind of a problem and another man with another kind of a problem in which he is particularly interested, we feel that the men are making good progress, because we are not endeavoring to put them on just the same plane. That same sort of thing can be done in this Altoona railroad high school; that same sort of thing can be done in the Buffalo railroad high school; that same sort of thing can be done in the Jersey City railroad high school.

The New York Central Lines are specially fortunate in having two men to undertake this work, one of whom can be called a practical man, and the other a graduate of the Massachusetts Institute of Technology, and who has had later experience in engineering construction. It is a happy combination in getting two men who can pull together so beautifully as team mates.

I would like to say in closing that I said yesterday no word with regard to the place of the graduate of the technical college. Some one met me after the meeting and said, "Why did not you jump on this scheme; the New York Central is not going to take any more of your boys who graduate from your engineering college into its lines." I said to my questioner, "You are entirely mistaken. I have talked with these people about this matter, and as an illustration told them there is one of my boys who will graduate next week, who applied to Mr. Cross and told him he was going to graduate, and that he had also had some practical experience working in railroad shops in the summer time, and they said to him, 'we will allow you two years for your educational experience, and summer vacation shop experience, and ask you to serve two more years in this apprenticeship course.'" That is fine — what I believe in exactly, and what most of you gentlemen believe in.

I am getting tired of the words "special apprentice." I am

getting tired of having a college man thinking he is going to be mollycoddled after he gets out of college. We do not want to mollycoddle him in college, and certainly you do not want to mollycoddle him after he gets out of college. I said one day last week to one of my students who was going on a Western road, and had a choice of many different positions, when he asked me what was the best thing for him to do, "The best thing for you to do is to ask the Superintendent of Motive Power on that road to make you a regular apprentice; serve for three years — I do not think you need to serve for four years, as you have had some experience in our college shops — serve three years, maybe he will let you out with two years — rely on his judgment — serve a regular apprenticeship and learn the machinist's trade; be a journeyman mechanic, and no matter how high you rise in the official scale later, the knowledge that you were a regular journeyman in your earlier days will always stand by you and your men will respect you more for it." I would like to see the graduate of the engineering college take a regular apprenticeship course, learn the trade, and having that foundation he can take care of himself and show whether he is useful to his employers for promotion later on.

Mr. H. Schlacks (D. & R. G. R. R.): I did not intend to say anything on this school system, because the system outlined as being in use on the New York Central is so much ahead of what we have; but I was requested to speak about the system that we inaugurated on the Illinois Central in 1874. At that time E. T. Jeffrey was the Assistant Superintendent of Machinery, and a friend of the apprentice boys. In the first place he issued an order that all the apprentice boys must be sons of mechanics and employees of the company. He had his particular reasons for that: First, the fathers helped to train them; second, it cemented the service so much better; and, third, Mr. Jeffrey being a friend of the workingman in general he adopted the night-school system, differing somewhat from the New York Central. It was put under the charge of the Mechanical Engineer. Besides the night school he compelled the Master Mechanic, a position I held at that time, to attend the school once a week. There were six hours a week night school for the boys. The company furnished

the room, the paper, the light and the teacher free, and the boys bought their own instruments. I believe the school is in existence yet. When we went to the Denver & Rio Grande Railroad, and were located at Denver, we immediately inaugurated a night school for the boys. In order to keep them together, they had to report in the evening. If one was missing we reported the fact to the father, who worked for the company, who would censure his boy for his non-attendance, and in this way we were able to keep the boys together, because they are inclined, not being paid for the time they spend in school, to go away to other places. The night school for boys on the Denver & Rio Grande is still in existence, and I believe that the night school on the Illinois Central, which was inaugurated in 1874, is also in existence. In the shops we had piece work, day work and special work. Both these night schools were of the very greatest advantage to the companies. The boys were taught a knowledge of drawing and other branches of work, and it qualified them to do their work for the company in a very much more satisfactory manner. The boys were able to lay out work closer and do better work for the company than they could have done without a knowledge of drawing.

At the end of the school term there was an examination held and prizes awarded for the best work in drawing, attendance, etc. These prizes amounted to from $25 to $40. Judgment for the awardance of the prizes was left to the students, who by ballot selected the best drawings. The closing exercises and the awardance of prizes was always attended by the operating officers of the road, including the General Manager.

MR. J. H. SETCHEL: Mr. President, I hope it is not understood from my remarks yesterday that I do not fully endorse this magnificent scheme of the New York Central to give its apprentices a practical, technical education, for that is what it is. The only thing that I question, and I still think, is that the main feature in which this will be found to be most useful is in making captains, as I said yesterday, of supervision. I think you will find very few of these apprentices in the boiler shop, in the blacksmith shop, or doing the more arduous work of either a manufacturing establishment or a railroad company; but in so far as

you can keep those men in that line as apprentices, just so far will it be valuable to them.

I want to notice a statement that was made yesterday, that in my judgment is entirely against what is being developed every day, and that is, as the gentleman expressed it, that he was tired of hearing the word "specialist." Why, sir, specialists rule the world in everything; in all the walks of life, the professional man and the mechanic, and the nearer he comes to being a specialist, the more he counts. Talk of being tired of specialists! Why, sir, I think it is an obvious fact that a man who does a thing continuously can do more of it and do it better than the man who only does it occasionally, and the man who attempts to teach in any other line will in my judgment make a big mistake. The man who works in a shop and is running a lathe as a specialist, talk about finding "hard spots," — I wonder if the man who runs a tire lathe for years does not find "hard spots," and does not know how to work them, too. Why, I am surprised that any such theory should be advocated. The specialist doctor who makes the eye, the ear, the nose or other things, his special study puts the general physician out of business. Specializing is what makes the world go and the nearer we get to that the faster we will travel.

MR. H. WADE HIBBARD (Cornell University): Mr. President — A correction of the gentleman's misunderstanding of my statement. I believe in a specialist, but I am very tired of the term "special apprentice," the mollycoddle apprentice.

MR. J. F. DEVOY (C. M. & St. P. Ry.): Mr. President, I desire to say a word as to the method by which the St. Paul Railroad handles its special apprentices. It would be a waste of time for me to attempt to compliment Mr. Cross, the author of this paper, because I have already done so, and I do not know of a more complete plan than that outlined by the New York Central Railroad. I desire to speak of the system which was inaugurated on the St. Paul Road some six years ago by the present Superintendent of Motive Power, Mr. Manchester. There had not been up to that time any particular line of work mapped out for apprentices, and we were called together to formulate some systematic plan. Some parts of that I wish to speak on, particularly

that relating to the teaching of drawing. You are doubtless aware that in the Western country there are a good many isolated roundhouse plants in which perhaps it might be difficult for the New York Central system or that advocated by them to be worked out with a great deal of satisfaction. Therefore it was decided that the last three months, or at any time at which it could be done, the apprentices should be sent to the Milwaukee shops, the principal shops of the road, to serve three months in the drawing-room. I have no desire to criticise any part of the plan of furnishing separate instructors; I believe it is right, but in this case I do believe that the proper place for an apprentice to be sent is to the big show. In order to explain what I mean, an apprentice should be sent to a mechanical engineer's office and there see what is being done in the construction both of cars or locomotives. The fact, and I am glad of it, that he does not see problems relating to geometry and all that sort of thing, the fact that you have cut that out, is one of the best moves that could be made. But I do still believe that his three months should be put in at the main shops so far as the Western road is concerned and should be carried out in that way. It should be continual. I am not speaking of the Eastern men, because there is much more opportunity for an apprentice to be taken care of and it is easier to get them, than in the West. I do believe that his entire instruction should be carried along from the time he starts until he has finished that particular course. So that I still maintain that Mr. Manchester's thought in having a man serve three months in testing and in the drawing office, as it works out, is perhaps the best that could be done.

Not to take up too much time and not to antagonize the views either of Professor Hibbard or Mr. Cross, or any one else — I do not wish either to credit or discredit Germany, but I do say that a boy properly educated in the eighth grade of the public schools of the United States is fit to take up an apprentice course in any shop. When we started this system I did not pay very much attention to it. All the apprentices came to the mechanical engineer's office to be examined and looked after and I did not pay much attention to the reason why boys failed until about after the first year, when I personally took up and looked over the

problems that they worked out, and I found that — now this is no reflection upon the ladies either — wherever you get an old woman of a pedagogue who has taught a boy how many parts he can divide an apple into, that is about what is taking up the boy's mind. If that teacher will start the boy out on about the lines that he should, something in practical life, the boy will pass that examination and get along well with it. I went much further. Pardon the personal part of it, but I became interested and I wanted to find out the reason why, and I know that any one of you gentlemen would, possibly, at first thought, criticise this — when I found that a boy did not pass certain examples, or something of that kind, about the first question I asked him was, "Did you ever have a fight with your teacher?" Well, they would look a little bit shy at me — but the boy who has quarreled with his teacher, or thought perhaps that he knew more than she did, invariably missed the examination. That is about all I care to say on that. The special apprentice system should still be kept up. I do not mean to be understood as criticising any one now, but it should be kept up. I say that a man who has a diploma from any technical institution in the United States and can not hold up his head because he is called a special apprentice, can not stand much beating and is not worthy of going out and taking his bumps. He ought to tell them that he is a special apprentice, and he ought not to be worked along certain lines, for instance a small lathe job or a shaper job, to begin with. That should have been done by the technical school, or as Professor Morse used to start us up Cornell, with a chipping block and hammer — and I have skinned off my fingers at it — but that should be taken care of by the instruction at the school, and that special apprentice should have been advanced a little bit further at least than the boy, say, sixteen years of age. You must take the apprentice course. I do not think I have anything further to say than to compliment again the gentlemen who have given us this paper.

Mr. E. A. Miller (N. Y. C. & St. L.): Mr. President, I feel that we are fortunate as a Master Mechanics' Association in having this very excellent paper by Mr. Cross. It is fortunate for the railroads of this country that the New York Central System should have so happily formulated and put in practice the course

for apprentice education that has been given to us, and I feel some satisfaction in the stand that Mr. Hibbard has taken to-day in regard to the special apprentice. My early experience was on the Pennsylvania Road, and I know of some boys who went away from the Pennsylvania System because they felt that if they did not go through the drafting-room at Altoona they were barred from the higher positions on the Pennsylvania Road. I might name some men that went out from the Pennsylvania and made good in later years that did not have the advantages of a special apprentice course. With all the good work of the Pennsylvania and all the very bright capable men they have on their roads and have sent out to other roads of this country, they have had some mollycoddles the same as other roads whom they were trying to make men of, who failed and were bolstered up by the practical men in the shops that they had charge of. [Applause.]

Without taking up the time of the convention, I presume that the apprentice system will now be practically settled and this will possibly be my last chance at this subject. [Laughter.] We have had it before us, as some of you know, for about fifteen years, and to go back to my remarks of the last year, you will understand that I can feel some satisfaction in the present status of apprentice education. In conclusion, I will say that the apprentice boy should have some one back of him that is interested sufficiently in his welfare to see that he has a fair show to make the best of himself. The fact is that in most, if not all shops, except where some special provision is made for the apprentice boy, they are not systematically advanced. That bright, capable apprentices are too often continued on one class of work, and if they are not capable, they are taken but little account of and allowed to drift along, so that between the two the incapable boy is simply allowed to drift along and the capable boy is kept on the work he is making good on. Every shop needs a man who is sufficiently interested and of capable judgment, to see that the apprentice boy gets a fair showing and then if he fails to make good, it is up to him to show the reason why. [Applause.]

Mr. F. P. Roesch (M. M. Southern Ry.): The bouquets are being rather unevenly distributed, Mr. President, so for the benefit of the Sunny South I would like to say that there has been

inaugurated in the Spencer shops of the Southern Railway during the past few months a system, while it is modified somewhat, yet practically on the same lines as laid down by Mr. Cross. We had some difficulty in getting the boys to take advantage of it or inducing them to come into the schoolroom. The principal trouble we found was due to the fact that most of the apprentices possessed only the rudiments of an elementary common school education and for this reason did not realize the benefits that they would obtain from a higher education or from taking advantage of the opportunities offered; but I am glad to say that we have overcome that to quite an extent. The boys are instructed during the working hours. They come into the classroom in their overalls, and, as Mr. Cross has stated in his paper, their thumb marks are found on their lessons. They are taught all the elementary branches as well as the higher branches. We find that with some of the boys it is necessary to commence at the beginning, to teach them the A, B, C's. From that on they are taught drawing, arithmetic, some of the elements of geometry, although not in a regular way; they are taught the strength of materials, what is the minimum cutting speed of the different steels and tools. The maximum cutting speeds we allow them to determine for themselves, and we find they are doing pretty well at that. We found that the best way to arouse enthusiasm in those who did not care to take advantage of this schooling was to allow those who were more advanced to make the shop drawings or shop sketches, signing their own names to these sketches. These sketches are of course checked by the instructors. When a few of these shop sketches are brought among the workmen and among the other boys, they make remarks, "Did Billy Dunn make this sketch? Where did he learn it?" "Over in the schoolroom." So now, not only the apprentices, but some of the mechanics, some of the helpers, have asked for the privilege of instruction. We find that not only the machinists but the boilermakers, the blacksmiths and the carmen are coming in. I believe that this system will eventually be developed all over the Southern roads wherever the larger shops are maintained. We are at present, as I said, just starting in.

MR. C. A. SELEY (C. R. I. & P.): Mr. Chairman and Gentlemen, this system as outlined in the paper has appealed to me very

particularly in regard to its directness of method. That which is taught in the colleges and schools is necessary for the rounding out of the education perhaps in various ways, but what this thing is for is to educate the rank and file. You can not keep down the boy who has it in him to be a future Master Mechanic. You can not make Master Mechanics by education. The issue has been raised, perhaps not on the floor, but in the minds of a good many, between the education of the technical schools and colleges and of the shop system. Unfortunately I did not have the opportunity of technical education and I can not speak from that side of it as well as I could otherwise, but I know from my own experience in handling men that each has to be considered as an individual, and he that has it in him to rise can not be kept down. The rank and file of the mechanics in our shops, as every motive power officer knows, have deteriorated, and this is the best method that I have seen of raising the standard of the rank and file, and it will provide, as the paper has said, for some foremen, and perhaps some Superintendents of Motive Power, from those getting that education, that you can not keep down.

THE PRESIDENT: Gentlemen, the time is running along pretty fast, and unless some one has something that he feels should be said on the subject particularly I think a motion to close the discussion will be in order, after Mr. Cross is given an opportunity to reply to the points that have been raised if he so desires.

MR. C. W. CROSS: Those of us who have served an apprenticeship at the mechanical trades will especially appreciate any effort to improve the environment under which the trade is learned. We remember with regret that there was no special advantage given us, but on the contrary there was in some instances an unwillingness to have the "cub," as he was called, get an opportunity to perform any of the good work. It was necessary for an ambitious boy to push himself on the attention of the foreman in order to get a change of work that would enable him to advance in learning the trade. In instances where a boy would notice a mechanic absent for a day and would ask to be put on the work, he was often told in language somewhat forceful to do what he was told only, and mind his own business. In a small shop there was usually only one or two men who could set valves. These men

were looked upon with awe by the "cubs," and they were very jealous of their superior knowledge, and took good care that none of the boys obtained any information in regard to the work. A remembrance of some of these things should cause us to take a special interest in establishing an apprenticeship upon lines that will enable the young men to learn the business rapidly and thoroughly. By this plan we can obtain and retain their love and loyalty and at the same time perform a service of genuine benefit to our employers.

In reply to the several questions I will say, in answer to Mr. McIntosh, that we find it very difficult to get desirable boys for apprentices in shops located near large cities. In shops located in villages we are able to get all that are needed of a very desirable class, many of them from the best families.

In answer to Professor Hibbard I will say that our efforts are directed to the moderate advancement along practical lines handled locally of a large number of young men, instead of the high advancement of a few. As has been mentioned, the genius will take care of himself in the race for advancement, as he always has done. There is no conflict between the training of the practical young man and the man from the college, but rather a correlation between them. These young men are given a time allowance on their course for previous experience in school shops and are considered perfectly able to take care of themselves in competition with others who have not had as good educational advantages as they have enjoyed. For instance, a certain young man about to graduate from one of the technical schools applied for a place as apprentice and was given two years allowed time on his course, starting him in at the third-year rate of pay, and he would serve two years at the trade and receive his certificate with the others. Professor Hibbard's suggestion that the instructors should meet occasionally for interchange of ideas is a good one and is approximated by our practice as referred to in the paper, of having the instructors make occasional trips of observation.

In answer to Mr. Setchel, I will read the second paragraph of the paper, which states that, "The purpose of the apprentice system is to provide the motive power department with an adequate

ecruiting system which will eventually produce from the ranks a rge number of skilled workmen, a number of foremen, a suffi- ient number of good draftsmen, a few Master Mechanics, and an ccasional Superintendent of Motive Power."

Also, replying to Mr. Setchel, this scheme is in no sense for ne favored few, but is for the benefit of the many.

In reply to Mr. Pratt, the locomotive firemen are trained, ducated and examined for promotion by a board of examiners omposed of Master Mechanics and road foremen of engines on ach road, and this work is not directly connected with the appren- iceship for the mechanical trade. The apprenticeship course does ot include any experience in locomotive firing. Mr. Pratt also nentioned the preference of the majority of young men for certain rades and the difficulty in obtaining desirable young men in the ther trades. This has been overcome to some extent by paying a igher rate of pay in some of the trades.

In reply to Mr. DeVoy I would state that it is our practice to nave apprentices transferred from one shop to another, also from ne drawing-room to another, to give them a more general experi- nce and to develop initiative. We all know that when a boy erves his time at one shop, and stays there after completing his ime, he is looked upon as a boy no matter how old he is, but if ne goes to another shop he becomes a man immediately.

To sum up I would say:

1. The need of a better system of training mechanics for the ailroad service is imperative, and I think need not be argued with ny one in touch with the situation.

2. The growing scarcity of skilled workmen is forcing itself n the attention of officers of railroads, and if a plan for recruiting ne service is not provided for at once, more serious difficulty vill be experienced in filling the ranks with competent workmen.

3. The inadequate supply of competent workmen has caused nany shops to resort to the use of what is termed "handy men"; nat is, adults who are broken in as specialists where mechanics an not be obtained. These men are not satisfactory, and are only olerated for the reasons stated. A plan of apprenticeship to roperly train young men in a thorough manner is the logical olution of the difficulty.

4. With regard to apprentices who are graduates of technical schools and usually designated as "special apprentices" — we assume these young men to be fully able to take care of themselves in competition with others who have not had as good educational chances as they have enjoyed.

5. The railroad company receive direct benefits by having the workmen quickly made familiar with the New York Central Lines standards. They are brought into close contact with the drafting-room and also on intimate relations with the shop draftsman. The mutual understanding between the men and the company is greatly improved. The ambition of the men is aroused.

6. The subject of a comprehensive plan of apprenticeship to provide for a supply of skilled workmen in the future, is one that should engage the serious attention of railroad officers as a matter of self-protection. There is no one item in the railroad service that is now more important than this one, not only for present and immediate benefits, but as an enduring monument to good management after we are gone and our places taken by others. [Applause.]

MR. A. M. WAITT: Mr. President, yesterday a motion was made and seconded that was to be put at this time, and if I may just renew it so that all will understand what it was.

THE PRESIDENT: I wish you would repeat it, Mr. Waitt. That occurred to me while Mr. Cross was speaking.

MR. WAITT: The motion was in substance, that in view of the evident interest taken in this subject and the importance that seems to be given to it, that it be placed in the hands of a competent committee to consider the developments and advancements in the apprenticeship system of education, during the coming year, and to report upon that, and also to consider the advisability of continuing or substituting something more up-to-date for our present Recommended Practice that is printed from year to year in our reports.

THE PRESIDENT: That was seconded yesterday. All in favor of that motion as stated by Mr. Waitt will signify it by saying "aye."

(The motion was carried.)

THE PRESIDENT: The topical discussion is now in order: "Is t desirable to eliminate water-gauge glasses on locomotives to nforce the use of gauge cocks?" To be opened by Mr. F. F. ;aines.

ELIMINATION OF WATER-GAUGE GLASSES.

MR. F. F. GAINES (C. of Ga. Ry.): Mr. President and Genlemen, the wording of this subject is such as to presuppose the uperiority of the water glass over the gauge cock, and from a ›ersonal standpoint I entirely agree with that supposition. We ıave, however, to consider the effect of eliminating the water ;lass from two standpoints. I might say the first will be decided ›y what might be termed a legal standpoint, and the second by he effect on operating. We will suppose for the sake of argunent an accident occurs due to low water on some railroad on vhich the water glass has been removed. What effect is it going o have on a jury to remove an admitted safety appliance? Is it ;oing to have an effect that is undesirable or is it going to have ıny effect at all? The other point is the effect on operation. I was connected with one railroad where we had no water glasses whatever, but used the gauge cocks entirely, and with another road where we were partly equipped with water glasses and gauge cocks, and both roads had occasional low water and occasional boiler explosions. The road I am now connected with I found equipped both with gauge cocks and water glasses. Recently one of our engineers lost an eye through the breaking ›f a water glass at a terminal while waiting to go out on a train. looked into the whole matter of the desirability of doing away ıtirely with the water glasses. I found when I got into the subct that probably about fifty per cent of our engineers depended her entirely on the gauge cocks or were sufficiently familiar th their use to handle their engine, and that of the other fifty r cent, some of them knew a little about using gauge cocks, but : majority of them depended entirely on the water glass. Under ıt condition of affairs I decided at the time to let the matter nd and not make any change. I think, however, there is a sirability of doing away with water glasses, but that we ought have something back of it to justify us in doing it. My idea that the matter should be very fully discussed and later put

to a vote of the Association as either a Recommended Practice or not, as the Association sees fit. In this connection I understand that one of our members has been making a considerable investigation into this matter and it is possible that he would be willing to speak upon the question, as he has some very important information to bring out that he has gathered in the course of his investigation.

THE PRESIDENT: Mr. Gaines, if you will let me have the name of the gentleman, if he is present, I would like to call upon him.

MR. GAINES: Mr. Gibbs.

MR. A. W. GIBBS (Penn. R. R.): Mr. President and Gentlemen, I think with Mr. Gaines that the water glass is hardly satisfactory principally because it may become misleading. Leakages above or below the water line give a false reading of the level, and stoppages in the connections always do so; many men do not take the trouble to notice whether the water level is surging — an indication that the connections are open. In New York State I believe a law has recently been passed to enforce the use of the water glass. Of all our divisions it so happens that the only one from whose locomotives the water-gauge glass has been removed is in New York State. My observation has been that where the gauge cock is the sole reliance and consequently, where everyone is accustomed to its use, it is a more reliable appliance. I have been on railroads that operated both with and without the glass.

MR. E. A. MILLER (N. Y. C. & St. L.): Mr. President, I might say as regards our experience with gauge cocks and water-gauge glasses, that I have found that enginemen who are trained to handle a locomotive by the use of the gauge cocks only prefer them, and I have had that class of engineers ask that the water-gauge glass be removed from the engine to which they were assigned. I have found on the other hand that men who were educated to running engines with the gauge cocks and the water-gauge glass were just as strenuous in their protest against doing away with the water-gauge glass; so that I think the preference one way or the other is very largely a matter of education on the part of the men. I might say for the benefit of any who have had a similar experience to that which we went through, that

some months ago we developed an epidemic of broken pistons, caused, as we believed, by men working water through their cylinders, due to carrying water too high in the boilers on the class of heavy consolidation engines that we had, and with which in handling, our men, especially the younger men, were not familiar. We have practically eliminated this trouble by changing the length of opening in the shield that covers the water-gauge glass from 8 inches to 5 inches.

WILLIAM MCINTOSH (C. R. R. of N. J.): Mr. President, I have been coming to these conventions for a number of years, and many others will remember that this is a subject that crops up periodically. It has been disposed of quite effectually on several occasions. For instance, I will refer to the convention of 1893, when the following resolution prevailed:

"*Resolved,* That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as absolutely necessary to the safe running of locomotives."

Now there is no question at all by any one who has had practical experience in the handling of locomotives that the water glass is an additional safety device, and it has also an additional advantage in regulating the position of the water level in the boiler. In cases where they have been extended too high, as Mr. Miller cites, it is simply a matter of detail that should have been understood and attended to. We have had to adopt the same precautions that he mentions in instances where carrying too much water was a disadvantage. But it is an additional precaution and it is an additional convenience to the engineer, and it seems to me we are wasting time in considering the idea of doing away with it. A glass will break occasionally, but there are now glasses of improved construction that although they break occasionally they will not fly. My experience in handling and being in charge of locomotives of nearly all classes, and extending pretty well across the continent, is, that with its use a great many cases of low water are avoided.

MR. DAVIS BROWN (D. L. & W. R. R.): Mr. President, I do not believe it would be policy for this Association to go on record as saying that the water glass should be abandoned.

I have noticed recently that they have to be applied by September on any engine running in New York State. Whether that is correct I am not able to state, but that is what I am given to understand. Mr. Miller made a change in his glass that I am in favor of, although instead of using a shield to shorten the sight of the glass I favor cutting the glass down. We know that a short glass will stand for a greater time than a long one and is not so apt to break. If we have the bottom nut of the glass in line with our bottom gauge cock, and the top nut of the glass in line with the third gauge cock, that will give us the distance between the bottom and the third cock for sight of the water. That is sufficient. It is not necessary to have a longer glass; the high pressure we are using at the present time to operate a short glass is better.

There is another thing about it. We can make a better fitting of our water glass frames. I know of some people who adjust these frames by the glass. That, in my opinion, is not correct. They should use a piece of iron turned down larger than the glass and have two bushes on it suited to the stem, as we call it, and set the frames to that. Taking that out and putting the smaller glass in, it is more liable to stand than if they are set with the glass.

There is one more thing I am in favor of. I have tried it and I know it works well. If you put the glass frame upside down from what it is at the present time, in other words, instead of blowing the water out and having the steam follow down through, let the water go up, it will never go out of the glass. There will be water all the time. You can clean the glass better, scouring it, and it is in better condition to observe the water. Furthermore, the temperature, in my judgment, is kept better in that way by the hot water being in it the whole time. You have not got to change from steam to water and vice versa; any scale that would lodge on the glass otherwise is not allowed to do so. It passes off in solution, whereas with the steam passing down through it, it dries, and a certain portion adheres to the glass. I recently saw a glass scaled on the inside so that you could not see the water, and to all appearances it looked as if it had been painted with aluminum.

Mr. G. L. Fowler: Mr. President, there is one matter suggested to me here, and that is the fact that it is quite possible that with an engineer who had been running on an engine provided both with the water glass and the gauges and had been depending upon the glass for some time, the gauges might be absolutely useless to him, and, in fact, he would not know how to use them. An engineer who has to depend entirely upon sound as to whether it is water or steam that is coming from his gauges — and I know in my own experience that it took me a long time before I felt absolutely certain in listening to the noise from the water gauge whether it was steam or water — I can readily understand that an engineer who had been depending upon the glass might have forgotten the sound of steam and water coming from the water gauges, and might not really know which it was.

Mr. Gaines: Referring to Mr. Fowler's remarks about the testing of water by sound I would like to say that on the road I formerly spoke of where they had no water glasses whatever, I found at one time in riding with some engineers at night time that they almost invariably carried a white lantern down in a little box in their cab and picked it up when they wanted to see where the water was. After I became aware of the reason why they carried that lantern and the trouble it was to look after it, I got up what you might call a gauge light that would shine directly on the gauge cocks so as to do away with the necessity of carrying the lantern; and while an average engineer can tell the difference between steam and water by sound I think very few of them like to rely on it when they are running an engine, and most of them will provide means to get a light on it in some way.

Mr. W. G. Wallace: Mr. President, I knew of an engineer at one time who carried a tin cup and opened the gauge cock and held the cup under it and got water. Then at night he had to have a light to find out whether he had water or steam in the cup.

This discussion has arisen often on the use of a water glass on a boiler. I believe the trouble we have had is simply due to its location; that with the different construction of boilers they are putting on water glasses which give the engineer a higher water level than he should carry in that particular kind of a boiler. As

an engineer I believe that the water glass should be left on the boiler. There is no objection to using the gauge cock. The engineer has so much to do now that many of them allow the firemen to pump the engine. That is a practice which should be discontinued, and I favor placing the injectors in such a position on the cab and on the boiler head that they will be operated by the engineer. I think the advantage is gained by the economy in fuel, and the carrying of water if you have the water glass at the proper length — do not have it too long — that we should retain or leave it optional with the roads in the different localities to use or discontinue the use of the water glass. I can readily appreciate Mr. Emerson's remarks that it is a bad-water country where as soon as you open the throttle the water goes this way [indicating]; it will drive an engineer insane, where if he has a good water it is a decided advantage to have a water glass, and in a bad-water country why, then he has to and must rely on the gauge cock. I think we are taking up valuable time of this Association, and move that the discussion be closed.

(The motion was carried.)

The President: It is now 1:30, time for adjournment until to-morrow morning, and I would like to request the members to be here so that we can open at 9:30 sharp.

FRIDAY'S SESSION.

JUNE 14.

President Deems called the meeting to order at 9:30 A.M., and announced as the first subject the individual paper by Mr. M. E. Wells, on the Causes of Leaks in Locomotive Boiler Tubes. The paper is as follows:

CAUSES OF LEAKS IN LOCOMOTIVE BOILER TUBES.

By MR. M. E. WELLS, A. M. M., Wheeling & Lake Erie R. R.

To the Members:

In order to obtain some new information on this subject, we sent out, to foreign countries as well as to the principal railways of the United States, a list of questions concerning the causes of leaks in locomotive boiler tubes. We made a mistake in saying, in the letters to foreign railways, that the questions referred to iron and steel boiler tubes and tube plates, as we used no other kind in the United States. On account of this, a number have replied that they could give us no information, since they use only copper for fire boxes and tube plates, and, in some cases, copper and brass tubes. The copper and brass tubes, however, are being replaced with soft steel. At first these steel tubes were reinforced with copper safe-ends at the fire-box tube plate, but the use of these is being discontinued, and they are setting the soft steel tube directly into the copper tube plate.

Some of the foreign railways, more thoughtful than myself, have given quite full answers to the questions, realizing, as I do now, that the causes of leaks in locomotive boiler tubes are practically the same, whether the tube plate is of copper or of steel; and it is interesting to note that if the causes for leaks given by each railroad were put on separate slips of paper, without the name of the road, it would be impossible to separate the foreign lists from those sent in by our own railroads, so identical are the causes given.

For convenience of discussion, our subject can be divided into two general heads:

First: Those leaks due to mechanical causes;

Second: Those leaks due to variations in temperature.

The first can be divided into four subheads — first, defective work at the time of first setting the tubes. This phase of the subject is receiving so much attention, and the practice of setting tubes is so uniform and well understood over the United States, that we scarcely feel it necessary to go further into it than to consider its effect on leakage. This, as a cause of tube leakage, is very slight, because almost any kind of a job done by an

apprentice boy in the front end will hold from one shopping of an engine to the next; while a much better job done by a skilled mechanic gives practically no trouble, and really never causes a delay, when done on the

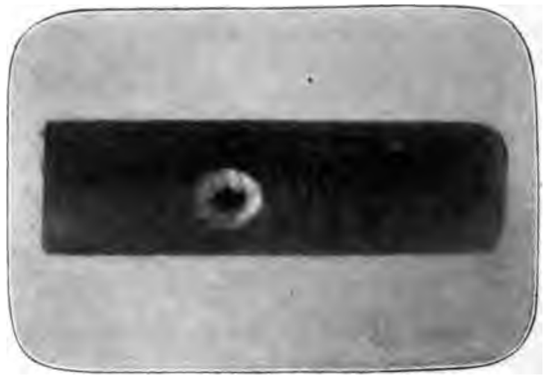


FIG. 1.

upper tubes in the fire box; and yet the most skilful job that it is possible for a skilled mechanic to do on the bottom tubes in the fire box will hold, at most, but a few days, in our largest boilers.

The second cause under this head, that of poor hurry-up work in running repairs, is a much more prolific source of trouble than any one of the other causes given under the head of "Mechanical," and yet the remedy is quickly stated — take time to do it well.

The third subhead is the possible cause of leaks on account of the vibration of the tubes. Much stress is put upon this by some, especially if long tubes are used. That tubes do vibrate vertically there is no doubt in my mind since finding in a boiler a tube, nineteen feet long, set so close to the bottom of the shell that a rivet head wore a hole through the tube. This is shown here in Fig. 1, reproduced from the November, 1905, Proceedings of the Western Railway Club, page 115. This vibration as a cause of leakage can not be considered very important, because if it was this action would certainly loosen the very simple job of tube setting done in the smoke box tube plate.

The fourth mechanical cause is the wearing out of the tube ends by the abrasive action of the cinders. This cause is suggested by the Northern Railway of France, and the same, or a similar condition, is referred to by the Pennsylvania Railroad, as "burnt-off and cracked beads, due to shallow fire boxes." We hope to be able to show further on in this discussion that the real cause of this condition is internal in the boiler, rather than external, and that, really, this cause should be classified under the second general head, namely, leaks due to variations of temperature.

Before leaving this phase of the subject, and by way of comparative interest, we wish to show illustrations of tube setting as reported by various countries. The method of setting tubes, with us, is so uniform, that I reproduce here an illustration of the process used by the Union Pacific Railroad (Fig. 2) as being practically standard for the United States. There is some difference of opinion among us as to when the rollers should be used, whether before or after the sectional expander (Prosser); and some roads do not use rollers in either first setting of tubes or in running repairs, while some use them in first setting but never in running repairs. However, these slight variations in method are of very little importance. Personally, I have never objected to the roller expanders, if they are used only to tighten the tube in the tube sheet; but when they are carelessly used to wear out and roll thin the material of the tube there is serious objection to their use. In England, France and Germany only roller expanders are used, the sectional, or Prosser expander, never being mentioned. Of the American railroads reporting, sixty per cent favor the sectional (Prosser) expander, forty per cent favoring the roller expander.

The Lancashire & Yorkshire Railway of England reports an electric motor for rolling tubes. My experience has shown this method very disastrous to tubes, because the operator could not tell when to stop, and the result was that tubes were actually rolled thin and worn out at the first setting. Air can be used for prossering and beading, but a motor for rolling we believe should never be used. Rolling, if done at all, should be done by hand and by a mechanic.

This same road enclosed a drawing (Fig. 3) showing the tube and ferrule at the fire-box end. The ferrules are welded and made from Swedish high carbon steel. Those made of solid drawn weldless tubing were found to be too soft. The ferrules are driven in by an ordinary drift. The fire-box tube plate is of copper, one inch thick, while the front tube plate is of steel, seven-eighths inch thick. This road does not bead over the end of the tube, while the North-Eastern Railway of England does.

The London & South-Western Railway reports that tubes in the fire box are expanded in the tube plate by a roller expander, and that the tubes in the bottom half are beaded over and ferruled.

The Great Eastern Railway of England reports tubes expanded with a roller expander and beaded; no ferrules used.

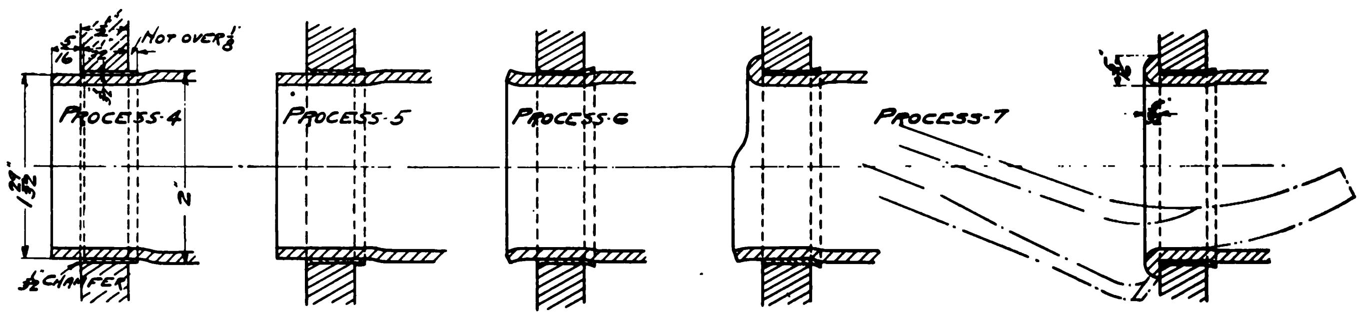


FIG. 2

METHOD OF SETTING FLUES.

1. All scale must be removed from flue hole by small air drill with small emery wheel on shaft of drill.
2. All scale must be removed from end of flue. This can be done by holding a square file on end of flue while being cut to length and flue is revolving.
3. Copper of proper thickness inserted and expanded in flue hole. Edge of copper should be 1-32 inch from face of flue sheet.
4. Flue inserted and pinned out.
5. Rolled with roller expander.
6. Expanded with Prosser sectional expander.
7. Beaded with standard beading tool.

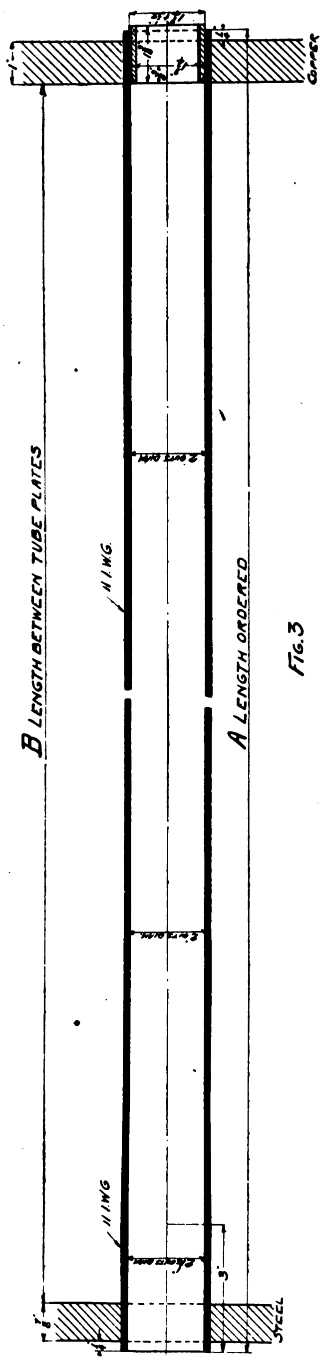
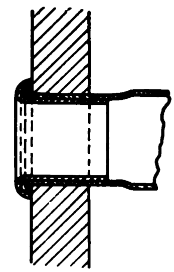

COPPER
B LENGTH BETWEEN TUBE PLATES
11 I.W.G.
A LENGTH ORDERED
11 I.W.G.
STEEL

FIG. 3

The Southern Railway of France says that their method consists in rolling and beading over the end of the tube, and then putting in a ferrule. When necessary to replace ferrules they sometimes replace the ordinary ferrule with one having a collar or bead, as shown in Fig. 4.



SOUTHERN RAILWAY
OF
FRANCE
FIG. 4

The Northern Railway of France says: "Our tubes of soft steel, 77mm (2.75 inches) in diameter, are swedged to 66mm (2.6 inches), and are rolled and beaded in the copper tube plate as shown." (Fig. 5.)

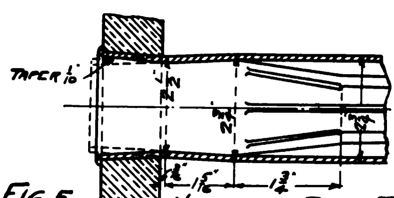


FIG. 5 NORTHERN RY. OF FRANCE.

The French have the same trouble we all have with the tube holes getting out of round, especially in the upper corners. This is the best kind of evidence that they have to roll and reroll their tubes frequently, to keep them tight, as we do. In the lower tubes, where they leak most often and therefore require more frequent rolling, they swedge the tube ends down to 60mm (2.66 inches) instead of 66mm (2.6 inches), thereby giving more metal in the bridges. The bridges for 2.75 inch tubes are from 0.66 of an inch to 0.79 of an inch, not counting the swedging.

The Eastern Railway of France reported in 1895 to the International Railway Congress as follows: "All tubes are expanded with Dudgeon's apparatus (i. e. rolled) and riveted or beaded. Ferrules are not used in steel tubes, but are still used in brass tubes." However now, in 1907, they

write: "We have only to report the use of steel tubes replacing brass tubes, and in the greater part of our new engines Serve tubes are being used. Our tubes are rolled and fortified by a steel conical ring." (A ferrule.) While some of the railways of Europe are getting away from the use of the steel ferrule here is a case where they have gone back to it.

The Royal Bavarian States Railroad uses a copper safe end on an iron tube. (Fig. 6.) It is simply rolled and beaded in the fire box, and only rolled in the front end. Note the increased strength of the safe end and the way they avoid shimming in the front end.

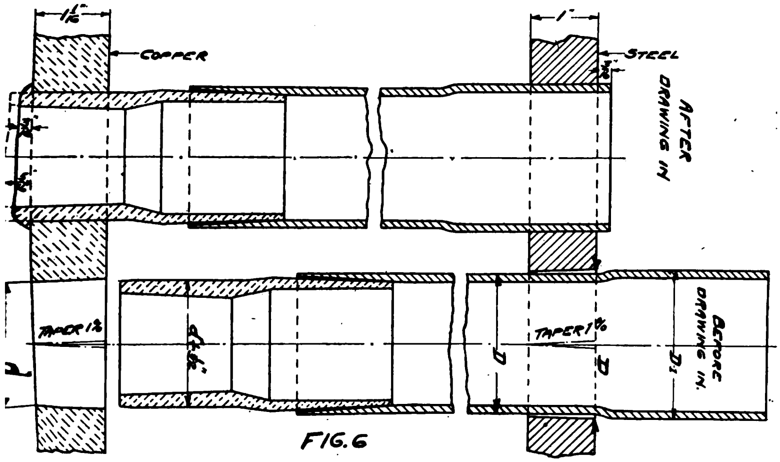


FIG. 6

Under the second general head of our subject, "Leaks Due to Varia-
ions of Temperature," we have two subheads; namely, causes of leaks
ue to equal variations of temperature, and those due to unequal variations
f temperature.

It can be clearly demonstrated that small damage is done to boiler
ibe joints when they are subjected to equal variations of temperature;
iat is, tube ends, fitted in a tube plate, can be heated up and cooled down
great number of times, and not become loosened, if all connected parts
e heated up and cooled down uniformly. By way of experiment, and to
etermine if the uniform heating up and cooling down can loosen a tube
a tube plate, we have made the following test: A piece of 2¼-inch
ibe was set in a ½-inch tube plate in the regular way. In order to be
le to detect the slightest loosening, the bead was chipped off and dressed
own so that the joint between the tube and the copper shim could be
riodically inspected by means of a strong magnifying glass. We also
ed the hammer test. For heating we used a gas oven, the average tem-
rature of which was about 450° F. This temperature was determined
r means of fusible metal of known fusing point. This test was carried

on through a period of about sixty days, and in that time this plate was heated up and cooled down an average of twice in twenty-four hours, through a range of about 400° F. In spite of the one hundred and twenty heatings and coolings the tube shows no signs whatever of loosening. From this we conclude that it takes something more than the uniform heating up and cooling down of a tube to loosen it in the tube plate. This we have also learned in a practical way from the fact that the top tubes in a fire box give practically no trouble from leaking, as compared with the bottom tubes, and yet these top tubes are subjected to slightly higher

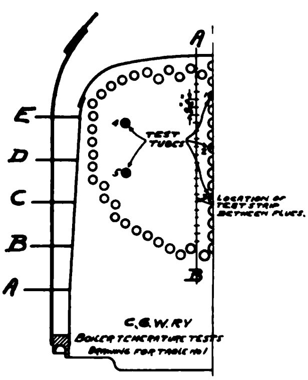


FIG. 7

SHOWING ACTION OF METAL ON LINE A-B:
M = MELTED - N = NOT MELTED - S = SLIGHTLY MELTED

No. 1			No. 2			No. 3			No. 4		
	Metal			Metal			Metal			Metal	
	380°	410°		380°	410°		380°	410°		380°	410°
0	M	S	0	M	S	0	M	S	0	M	S
2"	•	•	2"	•	•	2"	•	•	2	•	N
4	•	•	4	•	N	4	•	•	4	•	S
6	•	•	6	•	•	6	•	N	6	•	•
8	•	•	8	•	S	8	•	S	8	•	N
10	•	N	10	•	N	10	•	N	10	•	•
12	•	S	12	•	•	12	•	•	12	•	•
14	•	•	14	•	•	14	•	•	14	•	S
16	•	•	16	•	•	16	•	•	16	•	•
18	•	•	18	•	•	18	•	S	18	•	N
20	•	•	20	•	•	20	•	N	20	•	•
22	•	N	22	•	S	22	•	•	22	•	•
24	•	•	24	•	N	24	•	•	24	•	•
26	•	•	26	•	•	26	•	•	26	•	•
28	•	•	28	•	•	28	•		28	•	•
30	•	•	30	•	•	30	•	S	30	•	•
32	•	•	32	•	•	32	•	N	32	•	•
34	•	•	Side Sheet			34	•	•	34	•	•
36	•	•	Test			36	•	•	36	•	•
38	•	•	A	N	N	38	•	•	38	•	S
40	•	•	B	M	•	40	•	•	40	•	N
42	•	S	C	•	•	42	•	•	42	•	•
44	•	N	D	•	•	44	•	•	44	•	•
			E	•	•						

temperatures than the bottom tubes. The best proof of this we find in some tests made by the Chicago Great Western Railroad, and reported in the 1904 Proceedings of this Association (pages 220 to 223).

For convenience of reference we reproduce here one of these drawings (Fig. 7), showing the vertical line of fusible metal buttons, and the results of four tests. These show, conclusively, a hotter condition of the top tubes than of the bottom tubes. There is a very prevalent idea that the bottom tubes, being closer to the fire, are the hottest, and this is also commonly given as the cause of greater leakage in the bottom tubes. While the four tests given do not show that the top tubes are very much hotter than the bottom ones, yet they do show that the bottom tubes are not the hottest. We must therefore conclude that the deterioration and leakage of the bottom tubes in the fire box does not come from heat alone; the real secret being that we can not keep the bottom tubes hot enough — or at least uniformly hot — on account of the coolings constantly taking

place in the water space, due to the injection of feed water. Another significant fact in this connection is, that the tubes never leak in the front tube sheet. The argument that it is not as hot seems, in the past, to have put an end to this discussion. And while this is so, yet it averages practically one-third as hot — and one case is reported where, on a narrow fire-box boiler with short tubes, the front end temperature ran up to one-half that of the fire box — if there was really much action on the part of heat alone to loosen these joints, they certainly should be affected by this heat; but they are not loosened, even after months of service. And added to this, you have all seen the front ends of the tubes and the front tube sheet banked solid with scale, and still no leakage. Really, we do not know how long they would run and stay tight in the front end because it is always necessary to remove them, on account of fire-box leaks, long before they give any trouble in the smoke box. Let me repeat this conclusion as follows: If the bottom tubes in the fire box leak at regular intervals — and this is, at the best, every four or five days — why should not tubes leak after months of service, subjected to one-third or one-half the temperature of the fire box?

We are, therefore, led to the conclusion that there are causes, other han the equal variations of temperature, that really cause most of the eaks in boiler tubes. This brings us to the last and most important ivision of our subject, that of leaks due to unequal variations of temperaure. I want to first take up, under this head, the apparent cause of all auses. It is always given, and has been talked about more than all other uses put together. The opinion regarding the importance of this cause just as strong over Europe as it is in the United States. I refer to *ld air!* The opinion regarding the direful effects of cold air in causing aks in locomotive boilers is so universal, and so strongly held, that, were not so sure of my own position on the subject I should hesitate to dertake the task of trying to show you that its effect is really not very tent to cool boiler tubes and cause leaks.

In answer to one of the questions sent out for information, cold air, a cause of leakage, is the most universal answer given. In the same st of questions I asked the following: "With tubes and tube plates free incrustation, can cold air entering the fire box cool the metal any appreable amount below the temperature of the water in the boiler? The ajority of the answers to this question is "No"; and yet every one of e gentlemen so answering has given, in another part of their answers, ld air as a cause of tube leakage. I want to confess, right here, that I ticipated this when the questions were formulated.

If cold air entering a fire box can not cool a tube or boiler plate any ppreciable amount below the temperature of the water on the other side, hat serious effect can it have in producing unequal variations of temerature, which are the real causes of leaks. In arriving at this conclusion am fully cognizant of the fact that an incrusted tube or sheet may be lightly cooled on account of the inability of the heat of the water to get

through the scale to the tube or plate. But ordinarily, and with the ordinary scale formation, the cooling on account of cold air to cause leaks is practically harmless. If this is not sufficient argument to convince along this line, I am willing to carry this discussion to any extent that may be necessary.

I now want to draw your attention from this much-talked-of imaginary cause to the two real and important ones, namely, leaks due to deposits of incrustation, and those due to unequal variations of temperature produced by the varying water temperatures, especially those changes of water temperatures caused by the injection of feed water. These are the two great causes of all boiler leakage, and the two lines along which much improvement is yet possible.

A most important line to work along is the improvement of feed water, and yet good judgment must be used to guard against transforming a fairly good hard water district into an alkali district, that will give you so much foam that you can not pull cars. The benefits derived from a decrease of incrustation is beyond question; but when we must trade lime for soda there enters one of the most difficult problems that to-day confronts the railroad chemist. How much soda can we afford to take for the advantage of getting rid of a certain amount of incrusting water? This question should be carefully worked out for each operating district as a whole, before anything is done toward spending money for plants. We must pass this subject with giving you the formulæ of some home-made anti-incrusting compounds that have been in constant use for years past, and are still in use, on European and other railways. They are quoted from the proceedings of the International Railway Congress.

Prevention of Scale by Use of Disincrustants.

Quebracho.

The Buenos Ayres Great Southern Railway use a powder (manufactured) which contains about fifty-four per cent tannin, being probably prepared from the wood of "Quebracho Colorado." It is very satisfactory in its results, particularly as an anti-primer, and, since its introduction, scumming and blowing down on the road have been practically abandoned, fuel has been saved and the trains keep better time. It is mixed with water in a bucket and introduced by the injectors when the water shows milky in the gauge glass and priming begins.

The Central Argentine Railway use a powder (manufactured) which is believed to consist chiefly of quebracho sawdust and probably potash. It is a powerful disincrustant, and they find that its use enables engines to work longer without washing out and that in some cases it reduces priming.

The Hungarian State Railways sometimes use quebracho lye prepared as follows: To obtain 1,000 litres of lye a mixture of 200 kilograms of

quebracho sawdust, 50 kilograms of 80 per cent caustic soda lye is boiled with the required amount of water.

They use soda upon a larger scale, and in order that the deposit may not adhere mineral oil is poured simultaneously into the boiler.

They have also tried an anti-incrustant containing soda and tannic acid, and also a tannin extract simultaneously with soda.

The Western Railway of France adopt a disincrustant liquid made as follows:

Quebracho sawdust	24 kilograms.
Caustic soda	12 kilograms.

These materials are placed in a boiler of 100 litres capacity, water is added and the whole is boiled for three hours. The liquid, after standing for one hour, is then drawn off. Water in the same quantity as before is poured on to the residue, boiled for three hours, and the liquid drawn off as before. The two liquids thus obtained are then mixed together and the mixture when cold should indicate 11° to 12° Baumé.

The Southern Railway of France, where the *purification with soda and with lime is not satisfactory,* use a fluid extract of quebracho wood at the rate of 0.175 gram of tannin per 1 gram of lime or of combined magnesia in 1,000 litres of water vaporized.

South of France Railway use a disincrustant made as follows:

Water	100 litres.
Quebracho sawdust	24 kilograms.
Caustic soda	12 kilograms.

This is allowed to boil for three hours, and after settling is poured off. When cold it registers 11° to 12° Baumé. Four hundred grams of this mixture are poured into the boiler after each washing out, and 360 grams into the tank after a run of 100 kilometers (62.1 M). The cost of 1,000 gallons of water treated is 2.2 pence.

CAMPEACHY WOOD COMPOSITIONS.

The French State Railways introduce partly into the boiler and partly into the tender tank a liquid composed as follows:

Campeachy wood shavings	130 kilograms.
Carbonate of soda	150 kilograms.
Boiled in water	1,000 litres.

The quantity of this liquid required is calculated upon a proportion 0.0156 kilograms per cubic meter of water evaporated for every hydrotimetric degree.

The Madrid, Saragossa and Alicante Railway is trying at the present time campeachy wood mixed with a solution of carbonate of soda.

MIXTURES CONTAINING CAMPEACHY AND QUEBRACHO EXTRACTS.

The National Light Railways of Belgium (line from Brussels to Ixelles-Boendael) introduce into the boilers, after washing, 2 or 3 litres of the following mixture:

Carbonate of soda	13
Campeachy wood shavings	15
Quebracho wood sawdust	5

The Paris Orleans Railway answer this question very fully (see reply Appendix III). They have found the following the best composition for use as a disincrusting fluid:

Carbonate of soda	50	
Archil in paste	80	
Campeachy and quebracho wood	80	¾ campeachy wood extract. ¼ quebracho wood extract.

Water is added in the necessary quantity, so that the liquid may mark, after a prolonged boiling in a conical vat heated with steam, 8° to 10° on the salimeter. Owing to the difficulty of procuring archil cheaply, the above composition has been modified for some time as follows:

Carbonate of soda	60
Campeachy wood	75
Quebracho wood	25

Water.— A necessary quantity to bring the liquid after boiling to mark 8° or 10° on the salimeter. These compositions are placed in the boiler after every washing out and in the tender daily.

(For the proportions used see full reply in Question 7, Appendix III.)

It is recognized that the quantity used is correct when, in place of scale, mud is removed in washing out; on the other hand too much is used when priming is produced during running.

CHESTNUT WOOD EXTRACTS.

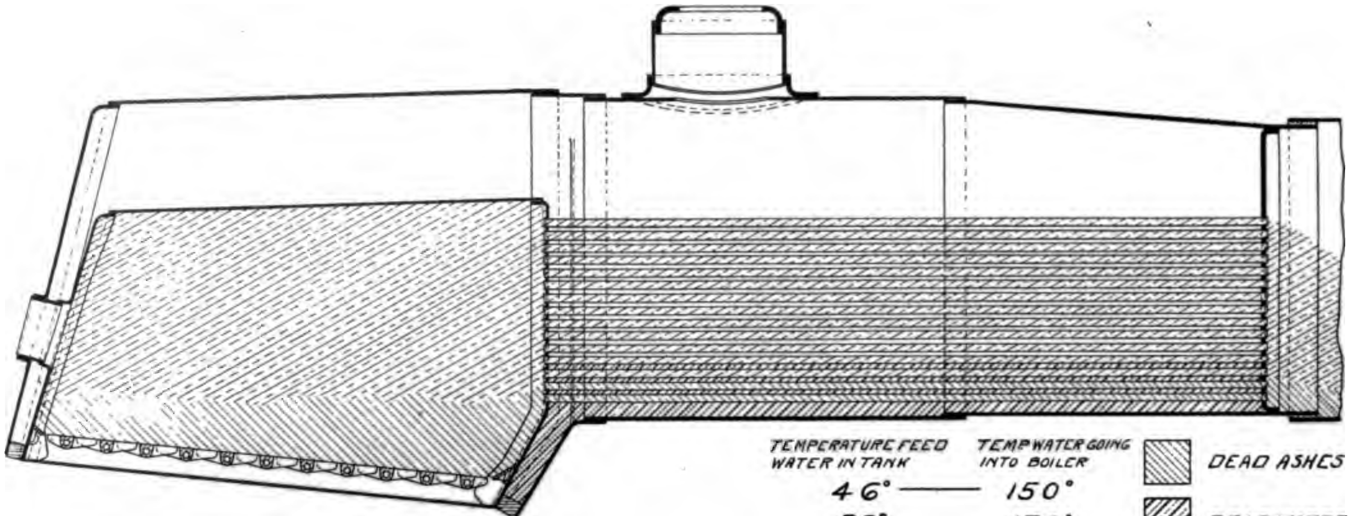
Eastern Railway of France used a liquid composed of the following:

Carbonate of soda (in powder)	10 kilograms.
Chestnut tree extract	12 kilograms.
Water	78 kilograms.

The chestnut tree extract marks 25° Baumé and contains on an average forty per cent of fixed matter of which thirty per cent is tannin. Two litres (3.5 pints) of this liquid are generally put into each tender per day's work of the engine, and 4 litres (7 pints) are put direct into each boiler after washing out. This operation occurs about every nine or ten days. So far this method of procedure has given good results.

This brings us to the subject of leaks produced by the unequal variations of temperature in the water space. So much has already been said and published along this line that we will be as brief as possible, and merely refer you again to tests showing the effects of injudiciously injected feed-water as a cause of leaks, as reported in the 1904 Proceedings of this Association (pages 231 to 241) by the Burlington Railroad. Recent reports from many roads in the United States show a marked interest in this phase of the subject, and an encouraging recognition of its importance. I am reproducing here (Figs. 8, 9 and 10) three drawings used by the Pere Marquette Railroad Company in the education of their enginemen, along this most important line of decreasing delays from leaky tubes. And in passing I want to commend this educational practice to you all, because there is scarcely a trip made by any of your enginemen but what, in most cases, it is dependent upon the crew as to whether they are delayed or not by leaky tubes. It is so important a factor that they should receive all the education possible along this line.

These illustrations (Figs. 8, 9 and 10) need no explanation — they speak for themselves. I do, however, wish to call your attention to Fig. 10. This is taken from Bryan Donkin's "Heat Efficiency of Steam Boilers," and from which is quoted the following remarks on this test: "This is the plotted results of five experiments on the Northern Railway of France on a locomotive boiler, divided into five water-tight compartments, showing the much greater evaporation near the fire box and then gradually decreasing. Briquettes were used as fuel. As the surfaces in contact with the fire and gases are further away from the fire box, the transmission of heat decreases, following a geometrical progression. The surfaces increase in arithmetical progression as the quantity of heat transmitted is proportional to the difference of temperature between the gases and the water (with clean surfaces)." This is one of the most interesting bits of boiler information I have ever run across, and is my only excuse for reproducing it for you. An attempt to get at the real cause of our tube and fire-box trouble has been a most vexing problem, and I want to say that this drawing has done more to clear the matter up for me than any other one thing. This shows us why our trouble is in the fire box and at the back end of the tubes. While the cooling and consequent pulling of the bottom tubes, on account of the shortening and lengthening, has some effect to cause leaks, yet, if this was the most important factor, it would certainly loosen the simple fastening of the tubes in the front end. There must be some other action. We know that the portion of the tube that is set in the tube plate actually shrinks, in some way, and gets smaller than the hole. We have learned to reduce, or, as we say, shrink a band by heating it and cooling half of it. It seems to me that we have just this same action on the back end of the tube; the heat of the fire box is tending to keep the bead and that portion of the tube which is set in the sheet up to a certain temperature, while the injected feed-water is cooling the tube in the water space. This gives us two temperatures, divided on the line of



TEMPERATURE FEED WATER IN TANK	TEMP WATER GOING INTO BOILER
46°	150°
52°	170°
76°	200°
90°	220°
100°	235°
115°	260°

FIG. 8

EFFECTS OF A DIRTY FIRE.

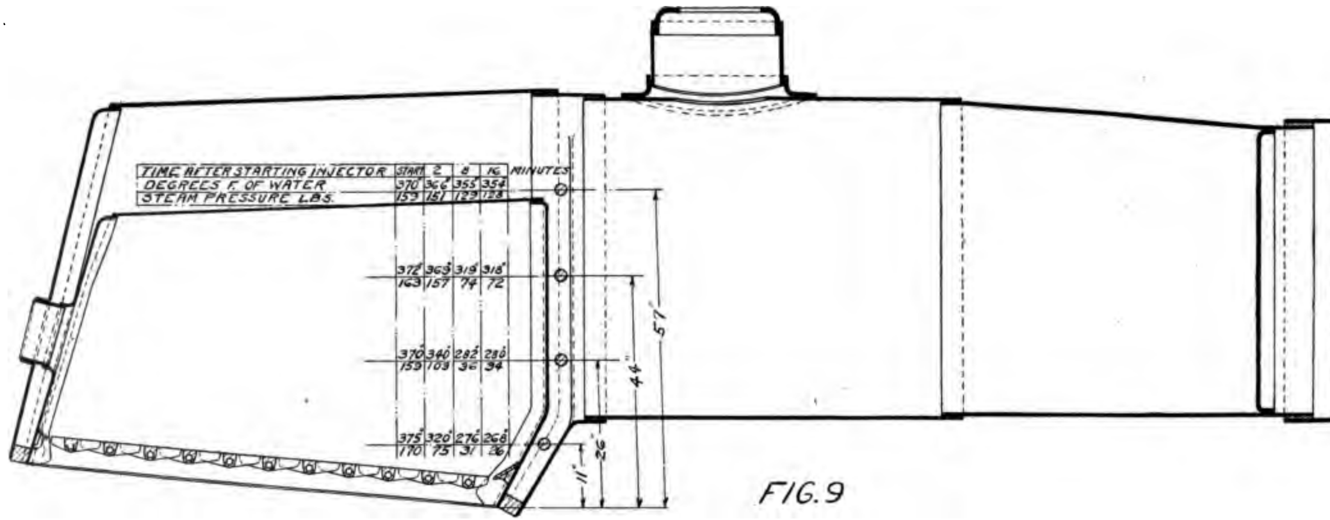
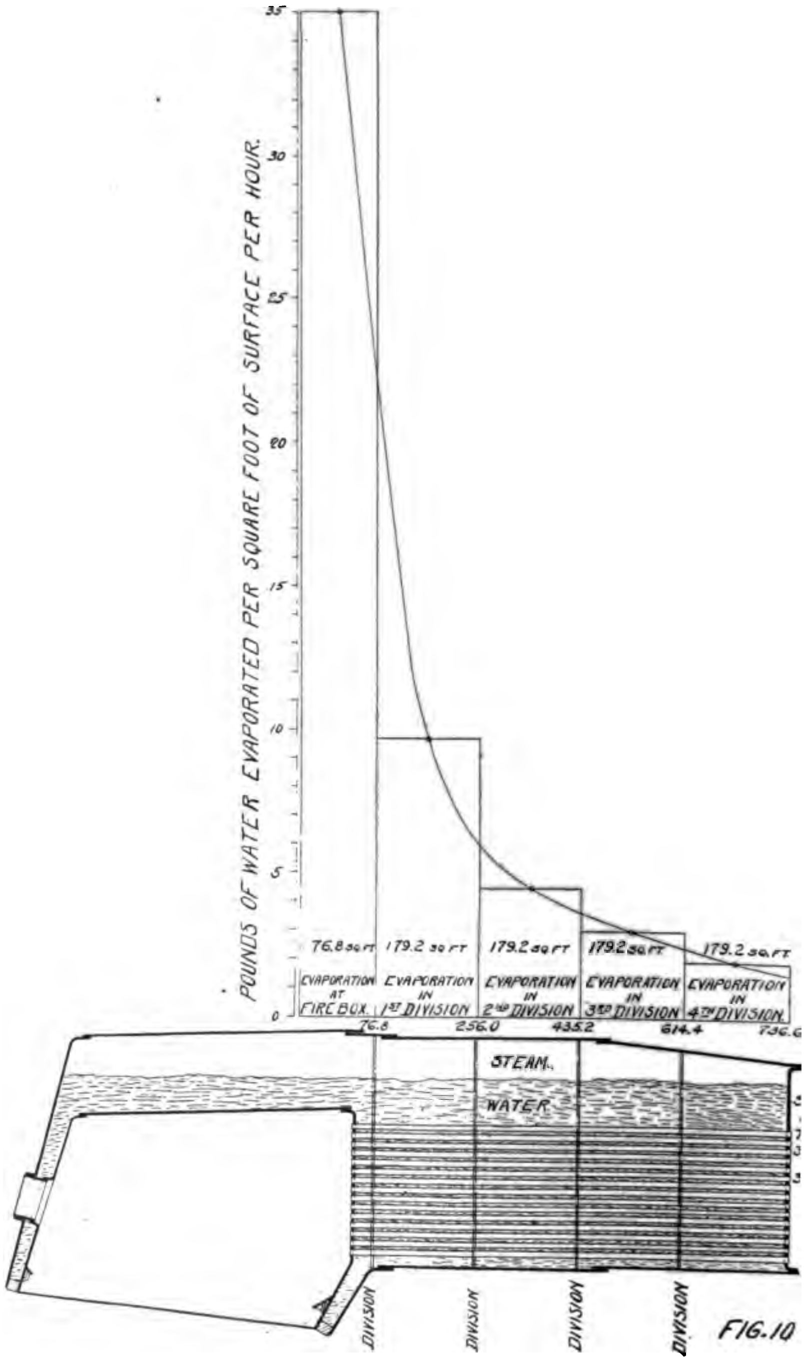


FIG. 9

EFFECTS OF WORKING INJECTOR WHEN ENGINE IS STANDING.



POUNDS OF WATER EVAPORATED PER SQUARE FOOT OF SURFACE PER HOUR.
35
30
25
20
15
10
5
0
76.8 SQ. FT.
179.2 SQ. FT.
179.2 SQ. FT.
179.2 SQ. FT.
179.2 SQ. FT.
EVAPORATION AT FIRE BOX.
EVAPORATION IN 1ST DIVISION
EVAPORATION IN 2ND DIVISION
EVAPORATION IN 3RD DIVISION
EVAPORATION IN 4TH DIVISION
76.8
256.0
435.2
614.4
STEAM.
WATER.
DIVISION
DIVISION
DIVISION
DIVISION

FIG. 10

the water side of the tube plate. This cooling and contracting in the water space actually upsets and makes smaller that portion of the tube set in the tube plate.

Fig. 10 shows why all feed-water goes toward the fire box, when the boiler is working, or under any condition of fire. And even when the fire is out this water will go toward the fire box, on account of naturally seeking the lower level of the water legs. So we see that, under either condition — fire or no fire — the low temperature feed-water goes toward the fire box. While the education of enginemen is a most important line to work along, yet I believe the members of this Association should be bending their energies along the line of changing the method of feeding, or using warmer water with which to feed, their locomotive boilers. If the temperature of the water entering boilers could be raised to a temperature corresponding to the maximum steam pressure, or if it could be heated to this same temperature after entering but before being liberated in the boiler proper, our boiler troubles would be wonderfully reduced, even when using average feed-water, because, as I have said before, our trouble is from cold water and not from cold air or burned tube ends and side sheets. I sometimes think that the prevalence of the cold air idea has come from the fact that almost every locomotive boiler ever built had the fire door on a line with the bottom tubes, and, in shallow fire boxes, on the line of most of our side sheet troubles; and, for want of better knowledge, we got into the habit of saying it was cold air, and the habit, like all other habits, is hard to change. I have had experience with large locomotives in the West which, on account of burning lignite coal and to reduce spark throwing, had very large arches fitted and cemented perfectly tight against the tube sheet, so that every particle of fire and gases had to come back and go over the top of the arch before reaching the tubes. The bottom tubes in these boilers leaked first, always, just as they do in any other boiler, and yet these bottom tubes were practically as free from the effects of so-called cold air as were the front ends of these same tubes.

I want to say a few words about the idea that much of this trouble in line with the fire door comes from overheating and burning off of the tube ends. In my opinion there is much misconception on this point. This trouble is the direct result of constantly changing and varying temperatures on the water side. To prove this, I want to call your attention again to the temperature test made on the Chicago & Great Western, shown in Fig. 7. You will note that a metal button, whose fusing point was eight degrees below the temperature of the water in the boiler, did not melt on the water side when placed ten inches from the mud ring, directly on this fire line along which we hear so much about side sheets burning out. Also, none of the buttons whose fusing point was 410° F. melted, and this is only 22° above the temperature of the water in the boiler. Note, also, the buttons, or strips, that were placed on the fire side of the tube sheet in these tests. Every one of the 380° F. strips melted, while every one of the 410° F. strips were either not melted at all or only

slightly affected. This test is most significant, and goes to show very conclusively that sheets in a fire box do not overheat to any serious extent. But the gentlemen making these tests seemed to be greatly disappointed because the sheets did not get hotter, and concluded that their method was not good. I should like to reproduce here many tests made and recorded in Donkin's work that check very closely with these tests made by the Chicago Great Western. But I can only commend the book to you, and will content myself with giving only their conclusions. One of them, a Dr. Hirsch, whose tests were made in Paris in 1890, and recorded in Donkin, pages 158 and 159, concludes as follows:

"If a sound boiler plate be in immediate contact with the water, it will safely bear exposure to the hottest fire, and the viscosity of the water does not prevent its wetting the plate." Also, he says, "If a boiler be kept clean and filled with water it may be exposed, without injury, to the strongest fire."

In this connection, Bryan Donkin says: "It should not be forgotten, however, that the temperature of clean iron plates, even over the fire, is only slightly above the temperature of the water on the other side."

The extensive and careful tests of Blechynden on the transmission of heat through boiler plates bring him to the following conclusion, recorded in Rowan, page 172: "The fact that the heat transmitted is proportional to the square of the differences of the temperatures of the two sides of the plate shows the importance of high furnace temperatures if efficiency is aimed at, and emphasizes the importance of rapid combustion."

Rowan, remarking on this statement, says: "We may accept these conclusions without endorsing all the statements connected with them. It is, for instance, evident that the temperature of the hot gases and the water, what may be termed the temperatures *at* the two sides of the plate, are confounded with the temperatures *of* the two surfaces of the plate itself. In consequence of the very minute degree of resistance in iron plates to the conduction of heat through the substance of the metal, *it is not likely that there can be any considerable difference of temperature between the two surfaces,* even while a large amount of heat may be passing per unit of time, per unit of surface. For the transmission of a large amount of heat there must, no doubt, be a large difference between the temperature of the hot gases and the temperature of the water. The two sets of differences are, therefore, far from being identical."

The best information received on fire box and front end temperatures is the following from the Pennsylvania Railroad, in answer to two of the questions sent out:

"*Question.*— When a boiler is being worked the hardest, what do you find the temperature of the fire in the fire box, or at the back end of the tubes, to be?

"*Answer.*— When burning 130 pounds of coal per square foot of grate, there is a temperature of about 2,300° (see Locomotive Tests and Exhibits, Pennsylvania Railroad, St. Louis, 1904, pages 695 to 699). With an Atlantic type of locomotive on the Testing Plant, when burning 168 pounds of coal per square foot of grate per hour, a temperature of 2,415° was obtained.

"*Question.*— When a boiler is being worked the hardest, what do you find the temperature in the smoke box or front end of the tubes to be?

"*Answer.*— For freight locomotives as developed at St. Louis, 574° to 757°. For passenger locomotives tested, 594° to 787°."

The temperature of boiler plates average about 75° hotter than the water in the boiler. In fact, we believe this to be high, because we have used for years soft plugs filled with 450° F. metal; and this is but 62° above the temperature of a boiler carrying two hundred pounds of steam.

Along the line of doing something to overcome the bad effects of injected feed water — and this is what I want, especially, to interest you in — the London & Southwestern Railway of England sends us the most interesting report received:

"We have given up the use of injectors. When injectors require renewing they are replaced by duplex pumps for feeding the boiler with hot water, heated by exhaust steam passing through steel tubes in the water tanks. I should think this would be a great advantage to your boilers.

"Our practice is to start the pumps when we start the train from a terminal station, and keep them constantly at work until stopping. This constant feed prevents any rapid difference in the temperature of the water in the boiler. We pass our feed water through the smoke box so that when it enters the boiler it is up to the same temperature. We mark the gauge glass giving the maximum and minimum height of water feed, our variation is one-half."

This road in another part of its report says: "We have little or no trouble with leaky tubes; and not such as to require attention between trips."

I hope you gentlemen will get an inspiration from what this English road is doing, and do something along the line of feeding your boilers with warmer water, or at least feed it into the boiler in such a manner that a low temperature water can not settle and circulate through the back ends of the bottom tubes and around the bottom of the fire-box sheets, thereby causing most of your boiler troubles. If I can impress this Association with the fact that a very large per cent of their tube and fire-box troubles would be over if they could only stop the destruction that is going on from this one agency alone, I shall feel that this paper has not been in vain.

MR. WELLS Mr. President and Gentlemen, in opening this subject I only propose to review briefly the paper; you have probably all read it. In a general way I want to say that any opinions I have given are formed only after the most careful research, trying to locate to the best of my ability the causes of leaks in locomotive boiler tubes. In preparing this paper I found it rather difficult to get something new on the subject, but felt that I must do so in order to have it of some interest. A gentleman talking with me yesterday morning very kindly said that there were several old points that needed considerable agitation, and I received some little encouragement from his suggestion.

In considering the causes of leaks in boiler tubes, I have only dealt with what I considered direct causes. There is a large list of indirect causes that are usually cited and talked about, but they only lead to these direct causes which I hope to point out. Among those indirect causes are the handling of the engine on the clinker pit, delays on side tracks, which are most important factors. One of the hardest propositions we are up against to-day is the long hours on the road, but while I call it a cause, I consider it as an indirect cause, since it brings the direct cause. I will not speak in detail of all the causes, but I want to speak especially of one of the mechanical causes — the possible loosening of tubes by vibration. After finding a tube in the bottom of a boiler with a hole worn through the under side by a rivet head, one is thoroughly convinced that there certainly was some vibration of the tube. (See Fig. No. 1.) In this connection I have just recently heard of something that is being done on a Southern road. I have understood they are putting about midway in the tubes an extra tube sheet with enlarged holes so as not to interfere with the circulation of the water. Just how they do it I do not know, but the point is to try to do away with the vibration.

I do not consider the vibration of the tube a serious cause. There must be something else, for if the vibration of the tube loosened joints, it would certainly loosen the joint in the front end, which is never made with the same care as the joint in the fire-box end. It has been a very unsatisfactory search to find some really genuine cause that makes the tube smaller than the

hole in the back tube sheet. There must be some cause in addition to the vibration.

Mr. Lewis, of the Norfolk & Western, handed me a communication yesterday from which I got some little information that was interesting, and I want to state to you that they are already getting in shape to make some further tests regarding the temperature at the top and bottom of the tube sheet. The point is often brought out, where the bottom tubes leak more than the top tubes, that they are hotter and closer to the fire. You will note that I have quoted a test on page 8, made by the Chicago Great Western Ry. in which four tests point to the fact that the top tubes are warmer than the bottom tubes. I believe this is a fact, because there is no question in my mind but that the crown sheet is the hottest sheet in the fire box. This is a contradiction of the customary idea that the fire line is the hottest. I am sure you will find that a sheet set vertically to a fire is never as hot as one set horizontally over the fire, although it may be a little farther from the fire. One of the things in this paper that I have tried to bring out is the fact that the deterioration of the bottom tubes and the sides of the fire box is not brought about by the fact that the sheet becomes hotter there than in any other place in the boiler, but on account of varying conditions in the water space.

Going back to the real cause that loosens the bottom tubes in the fire-box sheet, if you will turn to Fig. 10 you will find a test that I have reproduced there made by the Northern Railway of France.

This is an average of several tests which I believe to be accurate, although the criticism is possible that you do not have the same circulation in the boiler with the boiler divided into separate partitions that you would in the actual boiler, but it seems to me that it does show quite conclusively, and could be relied on in some measure to show, the large amount of evaporation around the fire box as compared to the front end of the tube. You see that around the fire box the evaporation is about thirty-five pounds of water per square foot of surface per hour, whereas at the front end of the tube it is two or three.

On account of this, the demand for water at the fire box is very great, and the circulation is toward the fire box when the

boiler is in operation. Surely there is no question of that. There is no need to dwell on the proposition as to where the feed water goes when it reaches the boiler; it goes to the bottom and back. This puts around the back end of the tube, on the inside of the tube sheet, this low temperature water. It must have some cooling effect, but just how much we can not say, because there is no test, but that it does have a cooling effect there is very little question. The contraction of the tube in this space directly on the inside of the sheet, I feel has quite an action to upset and make smaller the portion of the tube set in the tube plate, which has a tendency to be kept at a higher temperature on account of the fire. The real cause of it is the water largely. I do not say that it is true, it is only a suggestion, but I have hunted very carefully to try to locate the thing that really makes the tube smaller in the hole than the tube hole.

In attempting to get something new for you, I tried to get some information from foreign railways, and have shown a few sketches which are probably not of much value, but may be valuable in suggesting something to you.

In regard to the method of setting and material used, there is no question but that we are all trying to get the best material we can, and trying to do the best work we can, and I feel that it would take up unnecessary time to discuss very fully that phase of the question.

On pages 10, 11 and 12 are given some formulæ for boiler compounds. These have been in successful operation all over Europe for years and years. I want to call attention particularly to the center of page 11, where the South of France Railway says: "Where the purification of water with soda and with lime is not satisfactory, they use a fluid extract of quebracho wood at the rate of 0.175 gram of tannin per 1 gram of lime or of combined magnesia in 1,000 litres of water vaporized."

I want to call your attention to the fact that they are having the same experience on the water purification question all over Europe that we are having here; that they are running up against the question of foaming when treating water with soda.

On pages 14, 15 and 16, you will find cuts reproduced from some drawings sent me by the Pere Marquette R. R. They are used to educate enginemen along this most important line. And

while this is most important, and a great deal of good can come from it, it is a difficult problem — you run up against the same problem you have in lubrication; it is hard to get the men to do it.

There is one other point, and that is the causes of leaks from cold air.

I do not pretend to say I am right in the least on this subject, gentlemen; I am only giving you what I think about it with the best reason that is possible to be advanced on the subject, and the only reason I speak of it is because I want you to realize and appreciate the real thing, which is on the water side.

A splendid way to rectify it, is with your screw — they can do a great deal. The London & Southwestern Railway, of England, sent me a most encouraging report along that line, and I believe their system was developed entirely independently of anything that was being done in the United States. On the London & Southwestern, where an engine comes in that needs injectors renewed, they are taken off and they put on little duplex pumps. Mr. Drummond, M. E., of the London & Southwestern, says, " We start the pumps when we start the engine, and we shut off the pumps when we shut off the engine, and we maintain a uniform boiler feed. Our allowable variation in the water glass is one-half inch." If you could get your engineers to do that well with injectors, much of your boiler troubles would be over.

In regard to getting temperatures of sheets, I am sure when Mr. Forsyth made the suggestion yesterday about further tests that he did not have in mind merely trying the spacing of flues. He had in mind many other things that should be done. I think there is quite an erroneous idea as regards the temperature of sheets in fire boxes. The temperature of the fire in the fire box ranges not far from 2,000 to 2,400 degrees. The Pennsylvania tests at St. Louis gave 2,300 to 2,400 degrees. The temperature of the water, with 200 pounds of steam, is 388 degrees. The sheet ordinarily is seldom higher than 75 degrees above that. Any reasonable kind of boiler washing and keeping the sheets covered with water prevents any serious burning whatever. If I can get you gentlemen to realize that something should be done, in a mechanical way or automatic way, toward the introduction of feed water, I shall be pleased.

Mr. W. H. Lewis, of the N. & W. Ry., handed me a communication yesterday and there are a few points in it I want to speak about. He cites tests which show that a large amount of leakage comes after the engine is delivered on the dock or clinker pit, which we all know is true, and on account of that it is quite possible to run engines successfully and seldom have a leak on the road. On account of that, enginemen get into the habit of saying: I do not know what a leak is; the flues have been in for six months, and they have not needed any repairs. Now, gentlemen, I am interested in a set of flues that can run five or six months in any kind of a locomotive boiler that actually do not leak a little. I may point out to you with reference to these cases, where the engines are stated never to leak on the road, that Mr. Lewis says thirty or forty per cent, nearly half of them, come in dry and leak over the clinker pit, largely on account of filling them up to save the boilerwasher's job.

In answer to the question, "Have you made any changes in the introduction of feed water into the boilers on this account?" he says, "The effect of feed water entering the boiler and starting the flues to leaking is more noticeable when the water is injected into the side of the boiler. To overcome this feature we have on several of our boilers constructed an auxiliary dome which is located between the front of the boiler and the sand dome; this dome is filled with short section of tubes and the water injected into and among these is diffused so that by the time it has reached the bottom it is so nearly the temperature of the surrounding water that the difference in temperature is not so great as to cause such evil effects as where the water is injected low on the side of the boiler.

"The most important change in this connection was the application of a reinforced flue sheet, which consists of an auxiliary sheet placed eight inches ahead of the back flue sheet. This sheet is secured at regular intervals to the back flue sheet by means of a series of stay bolts. The auxiliary sheet has no other connection with the boiler, thus allowing it perfect freedom of adjustment in connection with the expansion and contraction of the flues and flue sheet. The water has free access to this plate on both sides. We believe with this auxiliary sheet a greater circulation of water at the flue sheet proper is obtained, thereby keeping the flue sheet

at a more uniform temperature and also carrying away such sediment as is likely to adhere to the flue sheet and result in scale."

There are other gentlemen in the room who have had some experience in the methods of putting feed water in the boiler to cause less trouble, and I will leave the subject for your consideration.

Mr. F. P. Roesch (Southern Ry.): Mr. President, I have listened to Mr. Wells' paper with great interest. We can not help but recognize Mr. Wells as a specialist and an authority in his particular line, that is, the care of boilers; yet, gentlemen, I am afraid that I will have to join the vast minority that can not agree with him on the difference in the temperature of the water in the boiler being the whole cause of flue trouble. I draw my conclusions as much from practical experience as from practical tests. I have been fortunate enough to have been located in countries where we had good water and bad water. I remember one particular instance in a bad-water country where a helper engine was located at an outside point. The engine never entered the terminal to be washed out, or to have the fire cleaned, or anything like that. In fact, the fire was in the engine continually for months. Strange to say that, while the particular water that this engine used was the worst water on the road, and while other engines passing through used the same water, and leaked, this engine did not. Afterward, when business picked up, more engines were placed at this particular point, and they did not leak. On the same railroad, farther down, there is one district called a particularly bad-water district. The life of flues in this district is about three months. After the flues become so weakened in that district that it is impossible to hold them, the engines are transferred to another district where the water is better, and after a little trouble at first, due to the change in water, the flues take up or stop leaking, and last there six months longer. The flues then become weakened in that district and the engine is again transferred to another district that has still better water, and the flues last nine months longer there.

Gentlemen, here is the point that I am trying to make — the question of flue leakage is exactly in ratio to the number of times the fire is knocked and the boiler is washed out. In this first

district I spoke of the engine was washed every round trip, and consequently, the fire was knocked. In the other district the engine was washed every week, and the fire was knocked only once a week. In the last district the engine was run for fifteen or thirty days without a washing, and during that time the fire was not knocked except possibly to repair grates or something like that. On another road, up in the mountains, where, if there would be any difference in the temperature of the feed water in the boiler, which none of us can contradict — in fact we know it, we know that there is more or less distortion due to this — but up in the mountains the fires are never knocked and flues last so long that we lose all record of them — twenty years — never wash the boilers, never bother with them.

A year ago I had occasion to make a test to see if cold air did actually have any effect on flues. We took an ordinary wide fire-box locomotive with 385 flues and put her over the cinder pit and knocked the fire. Preliminary to this test we opened up the front end and cleaned off one certain flue, perfectly clean, made smooth, made a long arm of wood, with a micrometer attachment in the rear end of it. After the fire was knocked out of this engine she still had 135 pounds pressure, or 358 degrees of heat, and the length of that one particular flue was taken right in the center of the box, and at the same time the corresponding length was inscribed on the side of the boiler. After the engine stood quiet for three hours and fifty minutes without any water being injected into the boiler at all the pressure had dropped down to 56 pounds or 305 degrees of heat. By measuring we found that the boiler had contracted just an even sixteenth of an inch in the length corresponding to the length of the flue, and this particular flue we took the length off was contracted 3-32 of an inch, showing that the flue through the action of the air through it had contracted more than the boiler itself. If heat from the fire can not pass through scale on a flue, then, conversely, the heat from the boiler can not pass through the scale the other way. Consequently we have a difference in the temperature of the flues and the water in the boiler. Another thing, air is passing straight through these tubes but it is not passing around the outside of the boiler, because that is protected by the lining and jacket.

After this engine stood two hours and thirty minutes longer the pressure was down to six pounds, or 233 degrees temperature. We found then that the boiler had contracted 14-64 inch, while the flue had contracted but 9-64 inch, showing that owing to the difference in the amount of metal in the boiler and flues, the final contraction of the boiler was greater than that of the flues, and consequently produced a pushing and pulling action on the flue sheets by the unequal contraction of the flues and boiler.

Not satisfied with that, we took another one. This engine had at the time 73 pounds of steam after the fire was knocked, and 320 degrees of heat. We took the measurements as before. The steam was all blown off, no water put in until the temperature dropped down to 180 degrees. We found in this instance that by blowing off the steam the boiler had contracted 6-64 inch. The top flue had shortened 8-64 inch, one of the middle flues had shortened 7-64 inch and the bottom flue 6-64 inch, or the same as the boiler. We then filled the boiler up with cold water, in addition to the hot water that was in there, through the injectors, by forcing it in. After the temperature fell to 40 degrees we found that the final contraction of the boiler was 14-64 inch, the top flues 16-64 inch, the middle flues 15-64 inch and the bottom flues 12-64 inch.

We then tried another one. In this instance we had 160 pounds of steam when the fire was knocked, temperature 363 degrees. Measurements were taken the same as before. In this instance the boiler was blown off and the water all let out of the boiler. By inserting a thermometer in the boiler we took the temperature, found it down to 172 degrees. We found that the boiler had contracted after blowing the water out, 10-64 inch, the top flues 9-64 inch, the middle flues 11-64 inch and the bottom flues 11-64 inch, which again shows a contradiction.

The boiler was then filled with water at 98 degrees, and the boiler contracted more, dropped down to 20-64 inch, top flues 18-64 inch, on the middle flues we lost the record, bottom flues 19-64 inch. I just bring this matter up to show you that there must be some action in there besides the action of cold water that would cause these flues to contract more than the boiler and to produce this forward and backward action.

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In connection with this subject, on the Santa Fe, in what used to be a bad-water district, or is yet in fact, it was the practice to wash the engines every round trip at one time. They have quit washing them now, that is to such an extent, by using blow-off cocks, and strange to say the life of the flues has increased, using the same water, at the same temperature that it has always been used at, but they are not knocking fires at the terminals like they used to. On another railroad I happened to be connected with, the feed water for the boiler is injected through an internal pipe at the back head, and before it mingles with the other water, it is practically at the same temperature as the water in the boiler, because this connecting pipe is about fifteen feet long. The flues on those engines leak just the same as any other. One time on the Union Pacific all engines were equipped in the front end with a Rushford heater. The water that went into the boiler was hot, or practically so, but the engines leaked. It is pretty hard to believe that the difference in temperature in the water in a boiler is responsible for all our flue troubles, and as I said before, I think you will find that the ratio is in exact relation to the number of times that our fires are knocked and our boilers are washed out.

Understand, I do not advocate never to wash a boiler, but I do advocate a more liberal use of the blow-off cock, and enough blow-off cocks so that the periods between washings can be materially extended, thereby avoiding the necessity of knocking the fire, as I am confident that where the fire is simply "banked" instead of knocked, the difference in contraction between the flues and the boiler will be much less, and the flue leakage will be reduced in proportion.

MR. W. E. SYMONS (Pioneer Cast Steel Truck Co.): Mr. President, this very interesting paper has brought out a number of useful points in connection with boiler operation, and while I fully agree with the author in regard to the effect varying temperatures have on leaky flue plates and seams, yet I am inclined to believe that we might safely go a step farther in laying a little more stress on the adverse effects of changing temperature due to air currents.

I do not recall any instances from personal knowledge of flues that have been in satisfactory service for twenty years. I think

ıat such a period of service is unusual. Their removal, however, ven at shorter periods, I am inclined to think is in many instances ırgely due to causes other than the temperature of feed water.

Taking for an illustration an engine with forty square feet of rate area burning 130 pounds of coal per square foot per grate rea per hour, there would be required approximately 104,000 ounds of air for perfect combustion, and as the weight of air is bout seven-one hundredths per cubic foot, it is a very easy matter ɔ calculate about how many cubic feet of air would be required. t is also quite easy to calculate how many heat units are necesarily absorbed in raising the temperature of the air thus used in ombustion, which is 1,300,000 cubic feet per hour, sometimes at ero temperature. From this calculation I think it is quite plain hat the sudden and varying temperatures resulting from air curents are quite as injurious as sudden change of temperatures esulting from other causes, and in my opinion the question of he injurious effects of air currents on boilers is equally as potent factor in connection with boiler operation and repairs as that of eed water.

As an illustration or proof of the effects of varying temperaıres on boilers, side sheets removed from fire boxes offer a good xample. As a rule, these plates are cracked on the surface next ɔ the fire, presenting in many instances a condition similar to ıat of a locomotive crank pin, or a journal bearing of a car which, aving become overheated, has been treated to an application of old water, thus causing the outer surface or skin to check, or rack. This for the reason, that the water acting as a conductor onveys the heat from the outer surface, or skin resulting in the ıetal contracting to its normal condition, while the inner portion s still expanded. It would seem reasonable to assume that sudden hanges in the temperature of the fire box referred to, resulting rom air currents, is responsible for a similar condition with side heets, in that the sudden lowering of the temperature caused a udden contraction of the surface of the plates thus in contact.

Flue ends subjected to the same conditions would also show similar effects, and, doubtless, the beads on the flue ends would, as the result of frequent variations in temperature, be affected thereby.

While the author has very properly referred to some of our customs as a habit, I am hardly prepared to agree that the cold-air habit is a harmless one.

It is customary on some foreign railways and a few American roads, when engines arrive at terminals to place a cap on the top of smoke stacks. This plate, or lid, is affixed to a shaft working on a hinge, so that it can be laid over the top of the smoke stack as soon as the fire is removed from the fire box of the engine, and in this manner prevent air currents causing injury to the fire box and flues; in fact, the device is intended to overcome just such defects or troubles as have been pointed out to us this morning as attributable to the change in temperature from feed water, and it would, therefore, seem to me reasonable to lay as much stress on the injurious effects of sudden changes of temperature due to air currents as to the evils of the varying temperatures of feed water.

As to the vibrations of flues, while I believe the positión of the author is well taken, yet I am inclined to think the trouble more frequently comes from what might be termed the pulling or pushing process resulting from expansion and contraction of the flue than the lack of a middle or central support, on account of the extreme length of the flue; this has been very clearly demonstrated in a manner similar to that described by the author.

I have personally known of engines with the lower flues one-half inch from the rivet head on the circilinear seams, which would sag down so that the flues bore heavily on the rivet heads, resulting in the rivet heads being worn off, or a hole worn into the flue, this resulting from firing up the boiler when filled with cold water, the expansion of the flue causing it to sag down until the boiler shell reached the same temperature, when the flue would resume its normal position.

In the matter of temperature due to air currents Government engineers not only in the preparation of material entering into boiler construction, but in the operation of steam boilers, are especially particular in guarding them from the injurious effects of air currents, laying as much stress on its adverse effects as on the injury that could result from any other sudden change of temperature, and I am inclined to think that, in considering the matter of the treatment of locomotive boilers we should place

more emphasis upon, and attach more importance to, changes of temperature due to air currents or draft in connection with that of feed waters, and by eliminating in so far as possible the evil effects of both, we would without doubt make great strides in the direction of reduced cost of maintenance and increased life of locomotive boilers. I am inclined to the belief that the air current, or air temperature, has as much to do with our present troubles as the feed water temperature.

C. A. SELEY (C. R. I. & P. Ry.) : Mr. President, this is a most interesting paper from the fact of its having so much information that is no doubt correct, as well as some points which are to a certain extent controversial, and there is no question but that gentlemen could discuss this paper on the floor all day with continued interest. I feel, however, that due to the hour and the amount of business we still have on hand, and the fact that the author of the paper has already discussed it as well as abstracted it, that we ought to close, but not to shut off from the Proceedings any expression which members may desire to add in discussion of this paper. I would suggest, Mr. President, that any written discussion be forwarded to the Secretary to be incorporated in the Proceedings, subject to answer by the author of the paper before printing. I move, therefore, that the discussion be closed.

(Carried).

MR. STRICKLAND L. KNEASS (Communicated: The paper presented by Mr. M. E. Wells, " Causes of Leakage of Locomotive Boiler Tubes," is a full and interesting discussion of the subject and contains much valuable data. It is the opinion of the writer that this leakage is largely due to the variation in the local differences of temperature. During the working of the locomotive there must be a difference in temperature between the different parts of the boiler; so long as this difference remains practically constant, there is little trouble due to leakage, but it is the inconstant value of this difference which produces the variation in lengths of the boiler tubes and causes the drawing or straining of the tubes in the end sheets and leakage at the ferrules.

The conclusion of the author of the paper that this is largely due to the method of feeding and to the temperature of the

entering water is thought by the writer to be correct; the question of the best solution is the problem.

If the feed water entered the boiler at the temperature of the steam, the problem would be largely solved; but under existing conditions the feed water can be distributed evenly and at a nearly constant temperature. This seems to be within the reach of possibility at the present time and may be approximated by the central delivery of the feed water, spread over as large a flue area as possible, and near the front end of the boiler.

The theory of keeping the feed water as hot as possible is also within the limits of present practice. It is probably inadvisable to do this by waste gases, as these are now applied on some railroads to add superheat to the steam. As it is necessary to use a waste product, there would be no advantage in using live steam from the boiler, for this can be more efficiently applied in the cylinders. The cylinder exhaust is not available, as it is difficult to arrange a practical construction for this purpose. On the other hand the exhaust from the air pump can be inducted to the tender tank and forms a convenient and available supply of waste heat.

The advantage of heating the feed water by a waste product is shown not only in the reduction in the flue leakage but also in the coal consumption, thus inducing a saving both in cost of maintenance and in expense of operation. An increase in the temperature of the feed water of 11 degrees obtains a saving of fuel of about one per cent. In this connection, it may be well to draw the attention of the Association to some experiments made on the Pere Marquette Railroad, during which the air-pump exhaust was used to heat the water supply. The boiler pressure was 200 pounds, temperature of water supply 50 degrees, feed water 175 degrees. With an evaporation of 3,000 gallons per hour at the rate of 7 pounds of water per pound of coal, the fuel consumption is, 3,571 pounds per hour. The temperature of the water supply was then increased by the admission of exhaust steam to 130 degrees and is shown by the test to be within the limit of practical working; under these conditions the temperature of the water entering the boiler was 255 degrees; an increase

of 80 degrees, due to the utilization of air-pump exhaust, with a saving in fuel of 7.6 per cent or 271 pounds of coal per hour.

To show the application of these tests to the reduction of flue leakage, it may be stated that when the water supply in the tank was raised to 130 degrees, the temperature of the entering water approached much more closely to that of the steam, which at 200 pounds boiler pressure is 387.8 degrees. When the water supply is 50 degrees, the temperature of the delivered water was 175 degrees. With hot water, however, the feed water was raised to 255 degrees, which is higher than can be handled by a pump; this is an increase of 80 thermal units per pound of feed water, gained from a waste source. Under this condition the smaller the difference between the temperature of the steam and that of the feed, the greater the conomy. In hot water test, this difference was reduced forty per cent. It is therefore obvious that with a constant boiler feed and heated water supply, there should be a considerable reduction in flue leakage as well as in the amount of coal consumed with a given load.

MR. E. A. MILLER: Referring to the discussion yesterday on the subject of special apprentices, I regret that the Philadelphia *Ledger* this morning should have misquoted the following remarks from myself: "That with all the good work of the Pennsylvania Road and all the very bright capable men that they have on their own road and have sent to other roads, that they have some mollycoddles, the same as other roads, that they were trying to make men of, but failed, and were bolstered up by the practical men of the shops of which they were in charge."

How these remarks could have been so construed as given by the *Ledger* I can not understand, and will simply say that I have a very high regard for the very excellent work that the Pennsylvania Road is doing to educate their apprentices, and if some of them prove to be mollycoddles, it is no fault of the Pennsylvania Road any more than it would be of any other road in their efforts to educate apprentices.

THE PRESIDENT: One subject that was passed yesterday, "Proper Width of Track on Curves, to Secure Best Results with Engines of Different Lengths of Rigid Wheel Base." Mr. F. M. Whyte has, I believe, a brief report on that.

Mr. F. M. Whyte (N. Y. C. Lines): Mr. President, this is a joint committee with the Maintenance of Way Association. The chairman of the Maintenance of Way Committee, Mr. Rose, is also chairman of the Joint Committee. We got together some data on the subject and had one meeting last winter. Soon after that Mr. Rose met with an accident which confined him to the house for some time and the work could not continue. The committee is not prepared to report. We suggest that the committee be continued.

(On motion of Mr. Seley, seconded by Mr. Walsh, the suggestion was adopted).

President Deems: The next report is that on Superheating, by Mr. Vaughan. It is as follows:

REPORT OF COMMITTEE ON SUPERHEATING.

To the President and Members of the American Railway Master Mechanics' Association:

Your committee on the progress made by Superheating on Locomotives during the past year begs to report as follows:

LOCOMOTIVES EQUIPPED.

There have been but few engines equipped with superheaters during the year 1906, with the exception of those constructed for the Canadian Pacific Railway. The following statement shows the engines in service December 31, 1905, and December 31, 1906, as reported by the members of this Association.

ROAD.	No. Superheaters. 1905.	No. Superheaters. 1906.	Type of Engine.	Class.	Type superheaters.
L. S. & M. S.......	0	-1	2-6-2	J-40	Cole.
	.....	1	2-6-2	J-40	Vaughan-Horsey.
C. B. & Q.	1	1	....	1989	Cole.
	......	2	....	2098	Schmidt smoke-tube.
Boston & Maine....	0	1	4-6-0	....	Cole.
C. & N.-W	1	1	4-4-2	....	Cole.
	1	0	4-6-0	....	Cole.
M. St. P. & S. S. M. .	2	1	....	....	Cole.
Rock Island System	2	2	4-4-2	....	Cole.
	4	4	4-6-2	....	Cole.
Canadian Pacific ...	1	1	4-6-0	D-3c	Schmidt smoke-box.
	1	1	4-6-0	D-6c	Schmidt smoke-tube.
	1	1	4-6-0	D-9a	Schmidt smoke-tube.
	10	10	4-6-0	D-10a	Schmidt smoke-tube.
	30	55	4-6-0	D-10b	Cole return-bend.
	10	45	4-6-0	D-10c	Vaughan-Horsey.
	5	5	4-6-0	D-11	Vaughan-Horsey.
	1	0	4-6-0	E-2c	Cole Field-tube.
	1	2	4-6-0	E-5de	Vaughan-Horsey.
	0	16	4-6-2	G-1-2	Vaughan-Horsey.
	20	20	2-8-0	M-4a	Schmidt smoke-tube.
	21	0	2-8-0	M-4b	Cole Field-tube.
	0	20	2-8-0	M-4c	Vaughan-Horsey.

From this table it will be seen that on the railways in the United States there were 11 engines with superheaters at the beginning of 1906 and 14 at the end of that year, 2 having been removed and 5 applied, and on the Canadian Pacific Railway there were 101 in service at the beginning and 176 at the end of the year, 22 having been removed and 97 applied. It is also of interest to state that during 1907 the Atchison, Topeka & Santa Fe and the Pittsburg, Shawmut & Northern have each received engines equipped with the "Vauclain" type of smoke-box superheater and that Purdue University locomotive Schenectady No. 2 has been equipped with a "Cole" return-bend superheater.

The Canadian Pacific also have received or on order 176 additional engines, all of which are equipped with the "Vaughan-Horsey" superheater.

Of the roads using superheaters, the Minneapolis, St. Paul & Sault Ste. Marie and Rock Island are unable to give any figures on coal consumption. The other roads report as follows:

Lake Shore & Michigan Southern.— Coal and water consumption were measured on Class J-40 engines with and without superheaters on several trips, and the average results are shown in the table below:

Engine	4653	4651	651	4658
Superheater	Cole	Vaughan-H	....	....
Date of tests	Apr., 1906	June 1906	Oct., 1903	Apr., 1906
Water used, pounds	65,660	59,650	72,225	76,260
Coal used, pounds	10,050	9,330	11,580	12,520
Water per pound coal	6.57	6.44	6.35	6.09
Water per S. O. ft. H. S. per hour	7.92	7.50	8.05	8.36
Coal per S. O. ft. G. A. per hour	76.8	73.8	89.5	95.0
Time on road, minutes	187	185	188	190
Running time, minutes	176	171	175	178
Average speed, miles per hour	48.6	50.2	48.9	48.0
Average steam pressure	196.4	189.0	196.0	198.8
Tonnage behind tender	414	398	347	428
Total tonnage	564	548	497	578
Ton miles	80,200	78,000	70,700	82,300
Water per ton mile	.82	.77	1.02	.93
Per cent	100	93.9	....	....
Per cent	80.4	75.5	100	....
Per cent	88.2	82.8	....	100
Coal per ton mile	.125	.020	.164	.154
Per cent	100	96	....	....
Per cent	76.2	73.2	100	....
Per cent	81.2	77.9	....	100
Size nozzle	$5\frac{3}{16}$-in.	$5\frac{1}{2}$-in.	$5\frac{1}{2}$-in.	$5\frac{1}{2}$-in.

Chicago, Burlington & Quincy.— The fuel consumption of engines equipped with "Cole" and "Schmidt" smoke-tube superheaters as compared with other engines of the same class, covering the months of October, November and December, is shown in the table below, the figure being pounds of coal consumed per 100 ton-miles:

	Oct. lbs.	Nov. lbs.	Dec. lbs.
Cole superheater engine 1989	17	15	
Average consumption of 9 engines of same class	16	16	
Average consumption of 11 engines of same class	—	—	
Schmidt superheater engines 2098 and 2099:			
Engine 2098	19	21	
Engine 2099	18	17	
Average consumption of 18 engines of same class	19	—	
Average consumption of 17 engines of same class	—	22	
Average consumption of 27 engines of same class	—	—	

Boston & Maine.— Comparative tests in heavy fast passenger engine vice over hard division between one engine with "Cole" return-bend type l another of the same class but without superheater gave the following ılts:

	Superheated.	Saturated.	Per cent. Gain.
ı-miles per 1,000 gallons of water..........	6366	5667	12.3
ı-miles per pound of coal.................	5.16	4.5	14.7

The average superheat obtained was 98.6°.

Chicago & North-Western.— Comparative tests made between idenl engines of the 4-4-2 and 4-6-0 type, equipped with the "Cole" superter and not so equipped, only such tests as were reliable being included, wed that the pounds of water per H.-P. hour were 7 per cent less and pounds of coal per H.-P. hour 9.2 per cent less with the superheater n without it.

Purdue University.— Prof. W. F. M. Goss reports as follows: "The erimental locomotive of Purdue University, which for several years been operated as a simple engine using saturated steam, was last sum· equipped with a 'Cole' superheater. In preparing the superheater it ; desired that the extent of superheating surface should be made as ;e as practicable in order that experiments with the engine might involve ıigh rates of superheating as practicable, and to this end a larger sacri- of direct heating surface was perhaps permitted than would ordinarily the case. The significant dimensions of the boiler before and after the nge, together with certain comparisons based thereon, are as follows:

"Heating surface of boiler as designed for supplying saturated steam ɔr to the time when it was fitted with a superheater:

Number of 2-inch flues..............................	200
Length of flues (feet)..............................	11.47
Heating surface in flues (fire side) (sq. ft.)..........	1086
Heating surface in firebox (sq. ft.)..................	126
Total heating surface (sq. ft.).......................	1212

"Heating and superheating of boilers as now equipped with the 'Cole' erheater:

Number of 2-inch flues..............................	111
Number of 5-inch flues..............................	16
Length of flues (feet)..............................	11.47
Heating surface in flues (sq. ft.).....................	817
Heating surface in firebox (sq. ft.)..................	126
Total direct heating surface (sq. ft.).................	943
Outside diameter of superheater tubes (inches)........	1¼
Number of loops	32
Average length of pipe per loop (ft.)................	17.27

Total superheating surface based upon outside surface of tubes only. Surface of headers neglected (sq. ft.) 193
Total heating and superheating surface (sq. ft.)........1136

COMPARISONS.

Number of 2-inch flues displaced by sixteen 5-inch flues necessary to give place to superheater............. 89
Reduction in direct heating surface resulting from the addition of superheater (ft.)..................... 269
Reduction in direct heating surface resulting from addition of superheater (per cent).................. 25
Reduction in transmitting surface (heating and superheating) involved by the application of superheater (ft.) 76
Reduction in transmitting surface (heating and superheating) involved by the application of superheater (per cent) 6

"At this date the experimental locomotive has been operated 3,300 miles since equipped with the superheater. Under normal conditions of running with a wide-open throttle the steam delivered at the header is superheated from 120° to 190° F., the precise amount depending upon the rate of power at which the boiler is operated. It is least when the rate of power is lowest and greatest when the rate of power is highest. Between the header and valve box there is a loss of 30° superheat, due, of course, to the cooling effect of the cylinder.

"While the data for the tests in question have not been entirely worked up, enough has been done to show that the consumption of superheated steam per horse-power hour varies from less than 20 to about 22 as maximum, this performance being under a wide-open throttle and at such speeds and cut-offs as are practicable. These values are to be compared with those obtained when the cylinders are supplied with saturated steam, which will range from 24 to 27 pounds.

"There has been no trouble arising through leaks either in superheater or in the large flues which accommodate the pipes."

The figures thus given for steam consumption with the superheaters are 83½ per cent and 81½ per cent respectively of the consumption of saturated steam.

Canadian Pacific.— On account of the large number of superheater engines on this road and the close attention paid to fuel consumption a quantity of records are available of the results in road service, but they are not in many cases available for comparative purposes on account of the small number of modern simple engines in use. Previous to the introduction of the superheater, compounds had for some years been constructed for freight service and a comparison of the superheater with the compound

:ntirely satisfactory, since it assumes that the compound is more
cal than the ordinary simple engine, which may not always be the
)uring the past year, however, the "Cole" field-tube superheaters
moved from the twenty-one engines of the M-4b class and they
a very satisfactory and economical simple engine, and they can in
ses be used as a basis for comparison. For the purposes of a record
›wing tables are given, showing the comparison of the superheater
with the M-4b simples, the D-9 compounds and the M-1-2 and M-3
ıds, the D-9 compounds being almost identical with the D-10 super-
while the M-1-2 are narrow firebox and the M-3 wide firebox con-
ıns of about ·85 per cent of the capacity of the M-4 simples and
ıters:

FREIGHT SERVICE.

	SUMMER.					WINTER.			
Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.	Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.
	D-10b	207¾	128	75		D-10b	3,298	193	86
Newport-	D-10c	370	163	96	Newport-	D-10c	1,037	187	83
Outremont	M-3	381	148	87	Outremont	M-3	2,145	211	94
	M-4b	5,877	170	100		M-4b	4,037	225	100
	M-4c	220½	108	64					
	D-10b	342¾	182	86		D-10b	3,873	274	101
Megantic-	D-10c	2,439	176	83	Megantic-	D-10c	2,951	233	86
Farnham	M-3	124¾	208	98	Farnham....	M-3	2,110	260	96
	M-4b	3,025	213	100		M-4b	10,026	271	100
	D-9	3,795	135	109		D-9	1,202	161	100
Smith Falls-	D-10b	7,410	124	100	Smith Falls-	D-10b	2,955	160	100
Havelock ...	D-10c	3,209	125	101	Havelock ..	D-10c	2,553	142	89
	M-1 2	373½	136	110		M-1-2	1,555	151	94
	D-9	494	147	100		D-9	431	190	96
Havelock-	D-10b	521	147	100	Havelock-	D-10b	319¼	199	100
Toronto.....	D-10c	501	136	93	Toronto.....	D-10c	273¾	150	76
	M-1-2	4,716	147	100		M-1-2	3,078	168	85
Chalk River-	D-10c	2,909	133	100	Chalk River-	D-10c	2,041	142	81
North Bay...	M-4-a	321½	102	77	North Bay...	M-4a	1,179	146	83
	M-4b	305	133	100		M-4b	1,094	176	100
	D-10b	311	138	98		D-10b	249¾	166	99
North Bay-	D-10c	2,257	118	84	North Bay-	D-10c	1,551	137	82
Cartier......	M-3	4,425	141	101	Cartier......	M-3	5,199	153	91
	M-4a	501	131	94		M-4a	496½	137	82
	M-4b	505	140	100		M-4b	768½	168	100

FREIGHT SERVICE—*Continued.*

SUMMER.					WINTER.				
Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.	Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.
Cartier-Chapleau....	D-10b	219½	121	94	Cartier-Chapleau. ..	D-10b	1,914	159	97
	D-10c	2,837	122	95		D-10c	2,604	152	93
	M-3	1,264	153	131		M-3	2,004	167	102
	M-4a	2,287	126	98		M-4a	5,366	153	94
	M-4b	502	128	100		M-4b	1,566	163	100
Chapleau-White River.	D-10b	716	133	92	Chapleau-White River .	D-10b	2,107	180	111
	D-10c	2,763	125	87		D-10c	2,436	149	92
	M-3	1,406	155	107		M-3	2,058	172	106
	M-4a	2,042	130	90		M-4a	4,471	155	96
	M-4b	403	144	100		M-4b	1,236	162	100
White River-Schreiber ...	D-10b	2,977	192	130	White River-Schreiber ...	D-10b	1,754	163	106
	D-10c	231	134	91		D-10c	1,291	155	101
	M-3	2,188	158	107		M-3	4,923	162	105
	M-4a	1,536	131	89		M-4a	2,144	166	108
	M-4b	1,312	147	100		M-4b	1,408	154	100
	M-4e	234½	125	85					
Schreiber-Ft. William .	D-10b	2,719	120	91	Schreiber-Ft. William .	D-10b	1,735	139	93
	D-10c	239½	118	89		D-10c	1,268	155	103
	M-3	2,051	137	104		M-3	4,111	143	95
	M-4a	1,176	116	88		M-4a	1,732	138	92
	M-4b	777½	132	100		M-4b	1,474	150	100
	M-4e	252¾	178	135					
Ft. William-Ignace......	D-9	967¾	97	98	Ft. William-Ignace......	D-9	4,217	105	111
	D-10b	2,381	99	100		D-10b	3,892	95	100
	D-10c	15,304	88	89		D-10c	9,230	102	107

FREIGHT SERVICE *Concluded.*

SUMMER.					WINTER.				
Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.	Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.
Ignace-Kenora	D-9	472½	95	100	Ignace-Kenora..	D-9			
	D-10a	741	96	101		D-10a	2,646	97	93
	D-10b	15,767	95	100		D-10b	13,759	104	100
	D-10c	113½	99	104		D-10c	671	128	123
	M-4e	3,173	89	90		M-4e	3,601	100	96
Kenora-Winnipeg	D-9	2,380	114	114	Kenora-Winnipeg ...	D-9	5,605	113	96
	D-10a	964¾	88	88		D-10a	2,085	101	86
	D-10b	16,514	100	100		D-10b	12,863	117	100
	D-10c	215	91	91		D-10c	337	91	121
Swift Current-Medicine Hat .	D-9	17,322	165	100	Swift Current-Medicine Hat	D-9	10,986	195	100
	D-10a	839¼	141	81		D-10a	945¼	178	91
	D-10b	778¾	168	102		D-10b	278¼	221	113
	M-1-2	1,567	194	117		M-1-2	6,605	197	101
Medicine Hat-Calgary.	D-9	1,443	146	100	Medicine Hat-Calgary.	D-9	164¼	224	100
	D-10a	616	122	84		D-10a	645	157	170
	M-1-2	6,058	155	107.		M-1-2	2,289	183	82
Field-Revelstoke ..	M-4b	1,158	317	100	Field-Revelstoke ..	M-4b	882¾	351	100
	M-4e	3,664	281	89		M-4e	3,872	305	87

PASSENGER SERVICE.

SUMMER.					WINTER.				
Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.	Section.	Class of Engine.	Coal Consumed.	Coal Consumed per Unit Mile.	Relative Consumption.
Havelock-Toronto.....	E-4-5 G-1-2	329 1,735	360 220	100 61	Havelock-Toronto.....	E-4-5 G-1-2	401½ 151¼	307 229	100 75
Chalk River-North Bay...	E-4-5 E-5de G-1-2	3,651 133½ 716	215 159 203	100 74 95	Chalk River-North Bay...	E-4-5 E-5de G-1-2	2,087 890 537½	249 191 233	100 77 94
North Bay-Cartier......	E-4-5 E-5de G-1-2	2,091 318 2,968	197 195 166	100 99 84	North Bay-Cartier......	E-4-5 E-5de G-1-2	1,165 57¾ 1,993	226 195 217	100 87 96
Cartier Chapleau....	E-4-5 E-5de	2,896 484¼	186 158	100 85	Cartier-Chapleau....	E-4-5 E-5de	2,360 549¼	213 234	100 109
Swift Current-Medicine Hat	D-9 D-10a D-10b	1,381 5,073 163	341 195 228	100 57 67	Swift Current-Medicine Hat	D-9 D-10a	1,110 3,682	346 265	100 77

While the above table is given as a matter of record it cannot be regarded as an accurate basis for comparison, as the movement of engine from one section to another and the variation in the monthly consumption due to weather and traffic conditions causes variations that may affect various classes of engines in a misleading manner. Some points are, however, worth attention. Whatever the relative merits of superheaters or compounds may be, the coal consumption of the D-10c engines between Fort William and Ignace is exceedingly good. On this division the average load for an engine having a drawbar pull, at 85 per cent, of 33,300 pounds, was 1,320 tons, but the consumption for six months was only 88 pounds per 1,000 ton-miles, and the speed is for freight service rather high, and as over 15,000 tons of coal were burned at this rate it will be seen that the rate is not accidental. An interesting difference between the compound and superheater is shown by the results in freight and passenger service between Swift Current and Medicine Hat. In freight the D-10a consumption was 86 per cent of that of the D-9 compound. In passenger it was 57.3 per cent, due to the lack of economy of the two cylinder compounds when handling passenger trains, while the efficiency of the superheater is relatively improved at short cut-offs.

In general the above table shows satisfactory results for the superheater, but it is difficult to estimate from them any exact figures of the saving obtained.

In place of relying on records taken over a period of several months, a method of comparison may be employed which, while laborious, is accurate if carefully compiled, namely, by comparing month by month and section by section the amount of coal actually burned by any class of engine with that which it would have burned had it used the same amount per unit of work as the class against which its efficiency is to be measured. For example: in August, between White River and Schreiber the M-4a engines used 249 tons of coal at 127 pounds per 1,000 ton-miles while the M-4b used 263 tons at 139 pounds. Taking the M-4b as a basis, had the M-4a consumed the same amount per 1,000 ton-miles they would have burned 272 tons in place of 249. By considering only those cases in which the class taken as a basis did sufficient work on any section in a month to render the comparison reliable, a series of results are obtained, which, when summed up give, over any required period and for any number of sections, the actual coal burned and the equivalent coal which would have been burned by any class of engine had its consumption been equal to that of the class with which it is being compared during each month on each section, subject only to the assumption that the unit conditions, as they may be termed, will equal. An advantage of this method is evidently that one favorable record has but little effect on the total result, and as each individual result is compared under similar conditions the sum total represents, with probably the greatest degree of accuracy that can be obtained from road records, the general result over a considerable period of time.

This method has been applied to the coal records on the Canadian Pacific where comparisons are possible, with the following results:

Class of engine taken as basis, M-4b, freight service:

Section or Division.	Class.	Coal Used.	Equivalent Coal.	Relative Consumption
Lake Superior	M-4a	8,474	9,414	90.0%
	D-10b	7,683	8,328	91.6%
	D-10c	....	....	90.6%
Newport-Montreal	D-10c	2,835	3,305	85.8%
	M-1-3	2,966	3,293	90.0%
	M-4e	220	342	64.2%
Megantic-Farnham	M-1-3	1,038	1,188	87.4%
	D-10c	2,548	2,920	87.3%
Field-Revelstoke	M-4e	7,536	8,830	85.3%

Class of engine taken as basis, E-5, passenger service:

Chalk River-North Bay	E-5de	1,617	2,015	80.2%
	G-1-2	915	1,012	90.4%
North Bay-Cartier	G-1-2	4,465	5,701	78.3%
Other Lake Superior	G-1-2	1,196	1,249	95.8%

Class of engine taken as basis, D-10c, freight service:

Eastern Division	D-10b	6,266	5,636	111.4%
Ontario Division	D-10b	6,315	5,816	108.6%

In these figures, neglecting M-4e between Newport and Outremont, where the amount of coal burned is insufficient to form a reliable opinion, there is evidently a saving in coal of from ten to fifteen per cent in the case of freight engines. It should be noted that on the Lake Superior Division the M-4 class, other things being equal, should show a result about five per cent better than the D-10, as on this division a consolidation engine, on account of the short one per cent grades, is more economical than a 10-wheeler. This accounts for the D-10 engines which obtain a rather higher superheat than the M-4a showing only the same saving as compared with the M-4b. From Newport to Outremont the 10-wheel type is slightly the more economical, as there is a long grade on which the reduced capacity of this type results in an improved coal performance 14.2 per cent and probably an average saving of 12 per cent would perhaps be about correct.

From Field to Revelstoke the service is very heavy, and the engine M-4e here compared to the M-4b are the later type superheaters with 175 pounds pressure, and the resulting saving of 14.7 per cent is very satisfactory.

An interesting result is the saving of 19.8 per cent made by the E-5d as compared with the E-5. The E-5a engines are converted 10-wheel passenger engines of the E-5 class and are identical except as regards the superheater, and these results, together with the general experience on the Canadian Pacific, show that the saving in passenger service is greater than in freight.

The G-1-2 results are not of much value, as the Pacific type engine is of far greater capacity than the E-5, but on certain runs where the work done has not been much increased they have shown a very large saving.

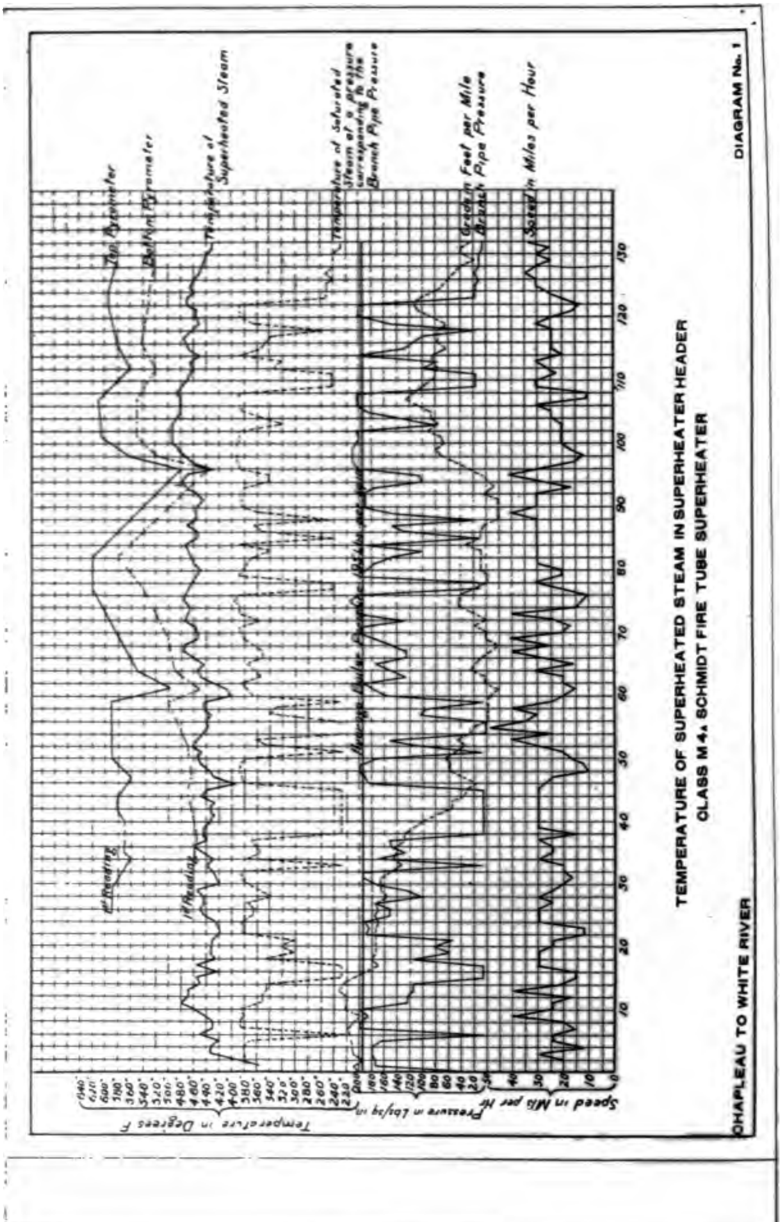
The D-10b show a result substantially equal to the D-10c on the Lake Superior Division but considerably poorer on the Ontario and Eastern Division, which is partly due to the leakage at the headers which developed in the latter case to a large extent, and is intended to show its action, which accounts for the poor results obtained on other roads when the same troubles have been experienced.

The records on the Canadian Pacific are fairly well in accordance with the tests on some of the other roads reporting and with those on the testing plant at Purdue. One fact is worth noting, that there is apparently a greater saving of coal than of water, the opposite of what might have been expected. This may be explained by the decrease in the efficiency of the locomotive boiler as the rate of evaporation increases, so that a saving of 10 per cent in steam consumption decreases the rate of combustion to an extent which renders the boiler more efficient, and results in a still greater saving in the coal consumption. It might be objected that some of the reports show but little saving, and the experience on the Canadian Pacific would confirm this, as they are accompanied by complaints of the leakage occurring at the header, and in that case whatever saving was effected by superheating would be lost by the engine not steaming freely. In general it would appear that superheating may be stated to show a saving of 10 per cent to 15 per cent of coal in freight service and 15 per cent to 20 per cent in passenger service, a result that must be considered satisfactory if not quite as revolutionary as the earlier reports would have indicated.

Some tests that are of interest have been made on the Canadian Pacific showing the amount of superheat obtained, and are shown in Figs. 1 to 8 attached. Figs. 1 and 2 show respectively the results obtained in the M-4a with "Schmidt" smoke tube and M-4b with "Cole" Field tube superheaters. The former gives an average temperature of about 460°, while the latter showed but little superheat, and on account of the difficulty in keeping the tubes clean and the small advantage obtained the apparatus has been removed and the engines used as simples. In these tests the temperature was taken in the branch pipe, but in those following it has been taken at the steam chest. Figs. 3 and 4 show two tests in class E-5d and show a temperature of 540° and 560°. These engines have twenty-two 5-inch

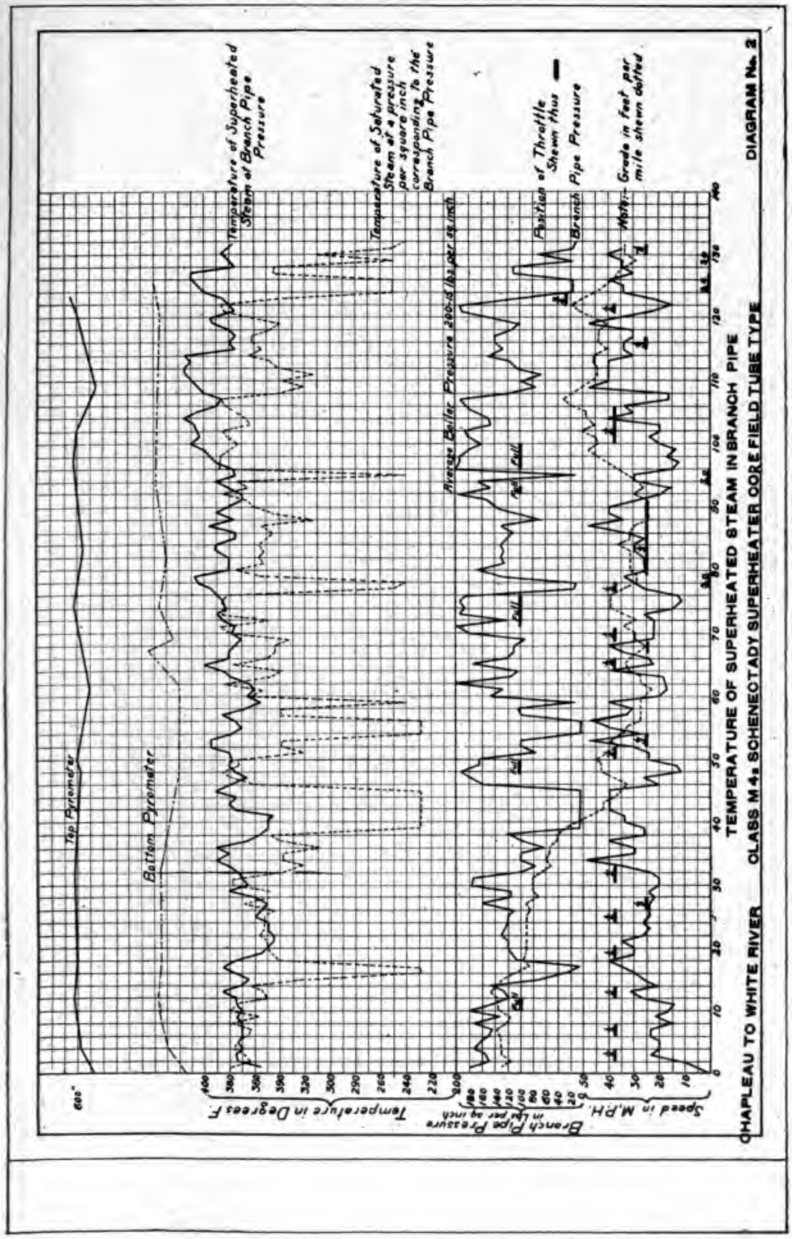
tubes in a 64-inch shell, the largest proportion of superheating surface so far tried, and have, as above mentioned, proved exceedingly economical and are reported to have a capacity of 5 per cent to 10 per cent greater than corresponding simple engines. Figs. 5 and 6 show tests of the D-10b and Figs. 7 and 8 of the D-10c engines, both having twenty-two 5-inch tubes, the former with the "Cole" and the latter with the "Vaughan-Horsey" superheater, the arrangement, with the exception of the headers, being practically identical. The former show temperatures of 460° to 470°, the latter 500° to 510°, the difference being due either to the more completely separated headers, or to the more even flow of steam.

Experiments have also been made to determine the loss in pressure through the superheater, and in an engine having twenty-two tubes each containing two return bend elements, and either of the M-4 or D-10 classes, it is found to be about 5 pounds under general working conditions.



TEMPERATURE OF SUPERHEATED STEAM IN SUPERHEATER HEADER
CLASS M 4. SCHMIDT FIRE TUBE SUPERHEATER

DIAGRAM No. 1

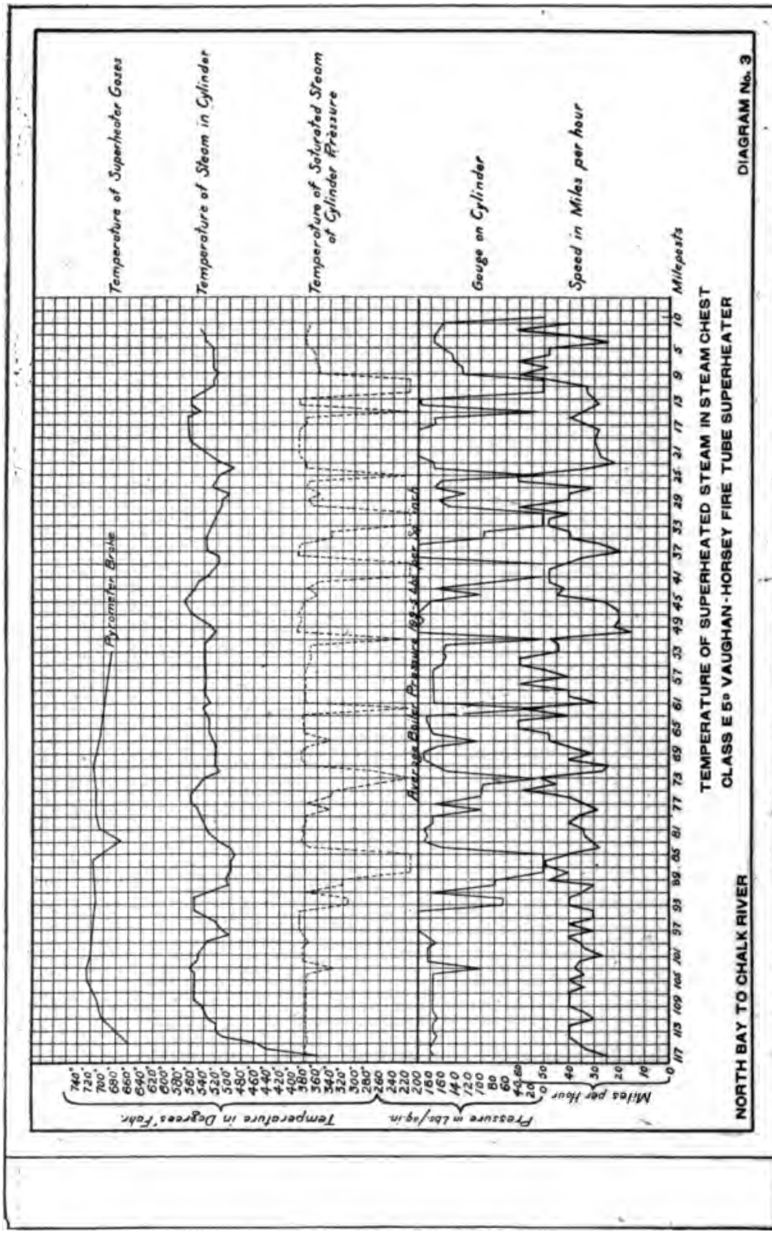


CHAPLEAU TO WHITE RIVER

TEMPERATURE OF SUPERHEATED STEAM IN BRANCH PIPE

CLASS M 4 a SCHENECTADY SUPERHEATER CORE FIELD TUBE TYPE

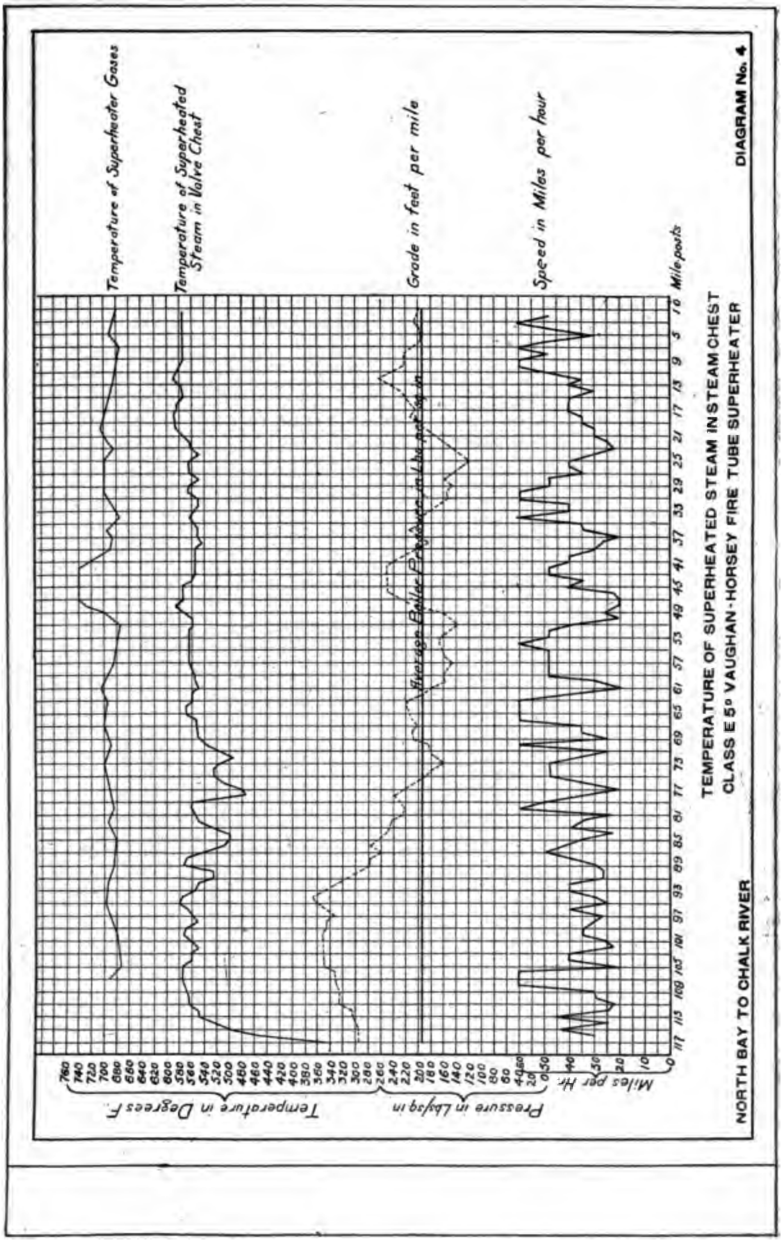
DIAGRAM No. 2

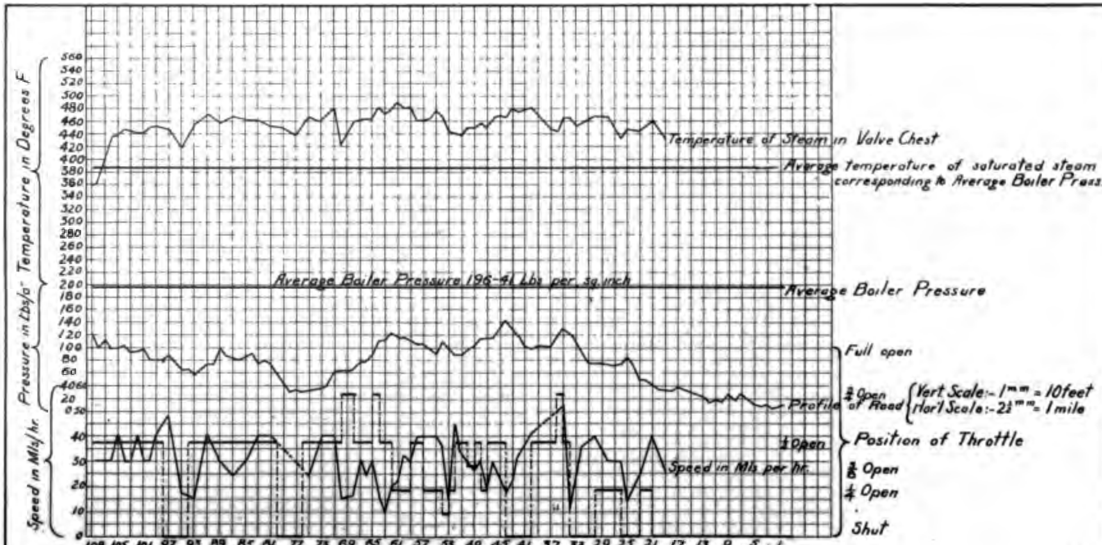


TEMPERATURE OF SUPERHEATED STEAM IN STEAM CHEST
CLASS E 5a VAUGHAN-HORSEY FIRE TUBE SUPERHEATER

NORTH BAY TO CHALK RIVER

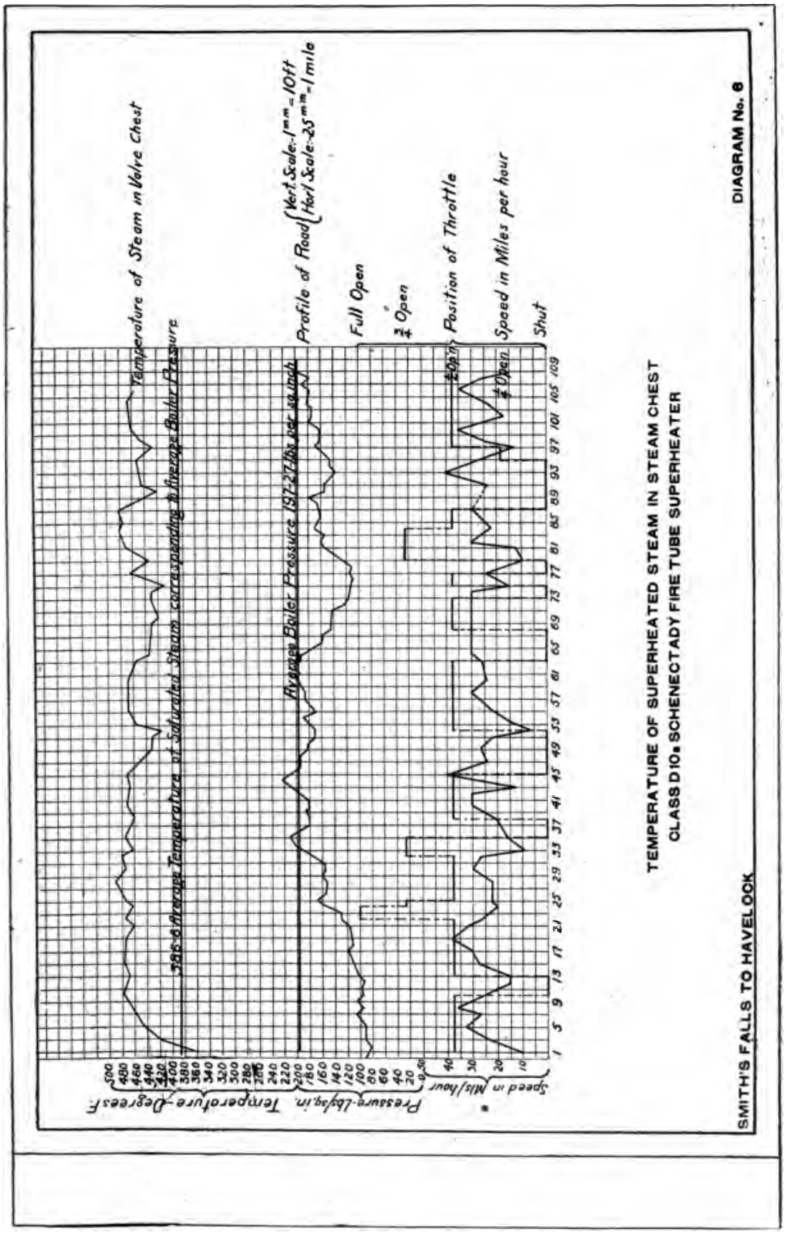
DIAGRAM No. 3


Temperature of Superheater Gases
Temperature of Superheated Steam in Valve Chest
Grade in feet per mile
Average Boiler Pressure in Lbs per sq in
Speed in Miles per hour
Mileposts
Temperature in Degrees F.
Pressure in Lbs/sq in
Miles per Hr.
NORTH BAY TO CHALK RIVER
TEMPERATURE OF SUPERHEATED STEAM IN STEAM CHEST
CLASS E 5° VAUGHAN-HORSEY FIRE TUBE SUPERHEATER
DIAGRAM No. 4



TEMPERATURE OF SUPERHEATED STEAM IN STEAM CHEST
CLASS D10a SCHENECTADY FIRE TUBE SUPERHEATER

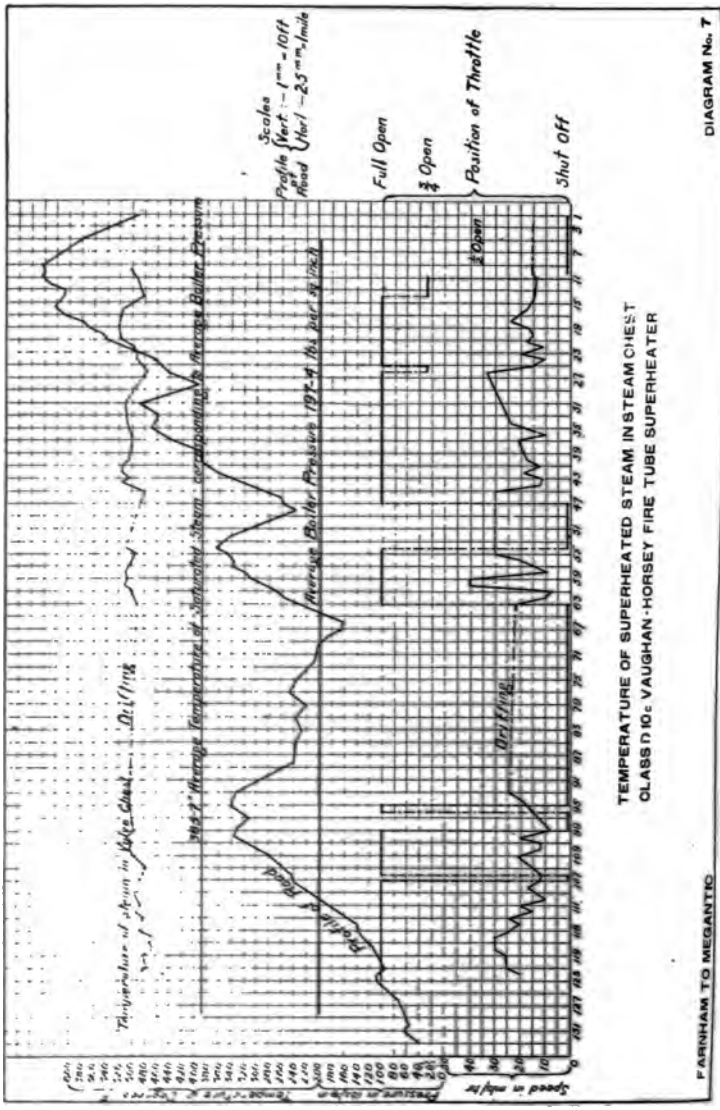
HAVELOCK TO SMITH'S FALLS **DIAGRAM No. 5**



TEMPERATURE OF SUPERHEATED STEAM IN STEAM CHEST
CLASS D10a SCHENECTADY FIRE TUBE SUPERHEATER

DIAGRAM No. 6

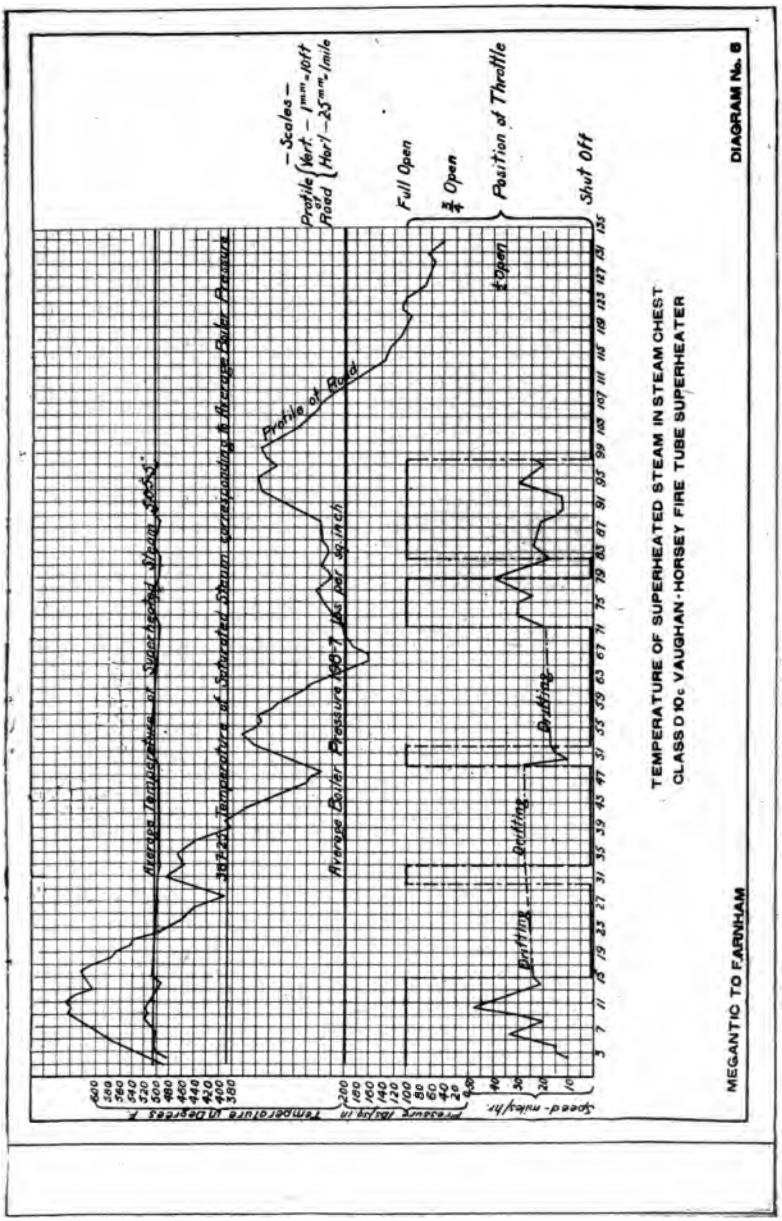
SMITH'S FALLS TO HAVELOCK



TEMPERATURE OF SUPERHEATED STEAM IN STEAM CHEST
CLASS D 10c VAUGHAN-HORSEY FIRE TUBE SUPERHEATER

FARNHAM TO MEGANTIC

DIAGRAM No. 7



-Scales-
Profile of Road {Vert. - 1mm = 10ft / Hor'l - 25mm = 1 mile
Full Open
3/4 Open
Position of Throttle
Shut Off
Average Temperature of Superheated Steam 505.5°
387.2° Temperature of Saturated Steam corresponding to Average Boiler Pressure
Average Boiler Pressure 190.7 lbs per sq. inch
Profile of Road
Drifting
1/2 Open
Temperature in Degrees F.
Pressure lbs/sq. in
Speed - miles/hr.
TEMPERATURE OF SUPERHEATED STEAM IN STEAM CHEST
CLASS D 10c VAUGHAN-HORSEY FIRE TUBE SUPERHEATER
DIAGRAM No. 6
MEGANTIC TO FARNHAM

MAINTENANCE.

All roads reporting, with the exception of the Lake Shore & Michigan Southern, have experienced considerable difficulty with the joints between the main and sub-headers on the "Cole" superheaters leaking, and this unfortunate defect has been a very important factor in the lack of interest shown in superheaters generally. On the Canadian Pacific, where a large number have been in service, the delay to power and failures through engines not steaming has been most serious, the more so since at first no remedy was developed. It is probably due to the shock in starting and switching causing the weight of the superheater pipes to work the sub-headers backward and forward and thus start the joints, and when once started the escaping steam cuts both the gasket and the seats away rapidly, and when once the latter are injured, remaking the joints is a tedious and difficult matter. It is also a peculiarity of the "Cole" superheater that it can leak very badly at the header joint and yet not affect the steaming qualities of the engine sufficiently to prevent its taking a train, and while this is an advantage in one respect it means, in busy times, that the joints are liable to get into a rather bad condition before they are attended to. Attempts are now being made to overcome this difficulty by securing a heavy angle-iron across the smoke box at the bottom of the headers, and fastening them to it so as to prevent their movement, also by increasing the bolting at the joints, and it is believed that this will remedy it.

The "Schmidt" superheater has, on the Canadian Pacific, given, in the majority of cases, exceedingly good results and has run from shopping to shopping with no attention. When for any reason the joints start it is very difficult indeed to get them tight without going over the face of the header and facing up the flange joints anew, and this work is slow and means considerable delay in a roundhouse. Should any leakage occur at a return bend there is also considerable work to make repairs if the leak occurs in the top or second row of pipes, on account of having to take down the bottom row to get at the others and having to make the joints over again in putting it up.

It takes two or three days to make the entire set of joints when the faces are in good condition, but this time may, of course, be increased if the joints have been leaking and the faces are cut, and the job is then a serious

The "Vaughan-Horsey" superheater gave considerable trouble at first on account of the fittings and nuts being made of bronze, which softened under the high temperature in front of the superheater tubes and frequently failed. During the past nine months these fittings and nuts have been made from steel forgings and this difficulty has been overcome. Some of the return ends of the superheater pipes also broke off, but it was found this was caused by the method of manufacture and they are now made [illegible] satisfactory results. Some pipes have pulled out of [illegible] caused by sufficient attention not being paid to their length

being correct, and they are now made as closely alike as the threads permit, namely, within 1-14 inch, and the longer pipe is attached to the upper header so as to equalize the difference in expansion. The only difficulty now being experienced is an occasional loosening of the nuts, and while this is not serious it is annoying, and has led to an occasional engine failure. A simple form of lock-nut is now being used which will prevent this, and it is hoped that this type of superheater will not add to an appreciable extent to the ordinary troubles of a locomotive.

There have been a number of cases of leakage at the return bends caused by a peculiar deterioration of the small pipes. This is due to the dampers not being properly maintained and allowing the tube ends to become overheated. After this is continued for several months the metal in the tube loses all its strength and can be broken by hand. The obvious remedy is, of course, the proper maintenance of the dampers, and this will require a better designed arrangement than has been employed in the past. The damper shaft has been too weak and the damper plate badly secured to it; the damper plate, in place of closing against a stop so that it could not bind, closed into an opening, and if it warped could stick, and if it stuck it was frequently blocked open; the damper cylinder was too small and the packing leaked, so that it was sometimes cut out and blocked to keep the damper open. There is not much difficulty in overcoming these troubles, but it may be stated that dampers must be operative or there will be trouble with the superheater pipes. In the "Vaughan-Horsey" design this is not very serious, as a leaky or defective pipe can be pulled out in a couple of hours, the joints blanked and the pipe put back when repaired at next wash-out, but with the "Cole" and "Schmidt" design it means taking down one or several sets of pipes with the chances of disturbing the joints on the remaining sets and very possibly a good deal of work to get everything tight again. In this connection it may be mentioned that possibly the present practice of making these pipes of solid drawn steel tubing is wrong. Iron tubing would be less affected by the heat than the steel and this material is to be tried in place of it. The large five-inch tubes have given very little trouble; in fact, in bad water districts in the West, they have been allowed to run through two sets of two-inch tubes with satisfactory results. There have been a few cases of their breaking at the threads, which has raised the question as to whether it is actually necessary to screw them into the back tube sheet, but this has not yet been decided.

The stopping up of the tubes seems to have been a peculiarity of the Field tube design. Probably the extreme end of this tube, which was not thoroughly cooled by the steam, became overheated and allowed a deposit to form on it. With the return bend type, even when using the same class of fuel that gave trouble with stopping up with the Field tubes, there has been no trouble except on the Chicago, Burlington & Quincy, so that it would appear that, with the majority of the coals in use, this difficulty is not serious.

COST OF REPAIRS.

The Chicago, Burlington & Quincy report the cost of repairs as follows:

	General Repairs.	Running Repairs.	Total.
Cole superheater engine 1989.......	$1,207.93	$ 913.69	$2,121.62
Average of 11 engines of same class..	1,215.49	1,239.95	2,637.27
Schmidt superheater engine 2098....	*......	335.20	335.20
Schmidt superheater engine 2099....	*......	422.34	422.34
Average of 54 engines of same class	....	163.98	163.98

*There were no general repairs to these engines account of being received new during the year.

This table is peculiar in that eleven engines of one class averaged $1,239.95 per annum for running repairs and fifty-four of another $163.98, which shows there are some conditions not taken into account. The experience with superheaters on this road was very unfortunate. The header on the locomotive with the "Cole" superheater could not be kept tight, and trouble was experienced with the "Schmidt" superheater, both with the joints between crotch pipe and the dry pipe and with the gasket joints on the superheater pipe flanges. They have also had several pipes break at the return bends and all round have had an excessive amount of trouble that would indicate the superheaters were not applied with sufficient care in the first place.

The cost of repairs to superheater engines on the Canadian Pacific has not shown any serious increase over simples. The M-4a engines have, to date, averaged 81,000 miles per engine, and the cost of running repairs by division and shop repairs has been as follows:

Division.	Mileage.	Running Repairs.	Per Mile.	Shop Repairs.	Per Mile.
Central	126,250	$ 3,122.54	$2.48	....	....
Pacific.	463,114	24,830.45	5.37	....	....
Western	13,871	206.74	1.49	....	....
Lake Superior ..	1,117,920	33,266.61	2.98	....	....
Total.	1,721,155	$61,426.34	$3.57	$36,099.57	$2.09

This shows a total cost per mile of 5.66 cents for an engine weighing ninety tons, which is a good result, and it should be noted that on the Pacific Division the cost is approximately double that on the others. This is on account of these engines when on that division being used in heavy hill service, and as this ratio will be found to hold in the other cases it is reasonably fair to consider one mile on the Pacific Division as equal to two miles on other divisions.

The M-4b had the superheaters removed after the engines had run an average of 28,000 miles each, and since that time they have run 58,500 miles each, or a total average of 86,500 miles. The cost of repairs before and after the superheaters were removed was as follows:

Average of 28,000 miles prior to removal of superheater:

Division.	Mileage.	Running Repairs.	Per Mile.	Shop Repairs.	Per Mile.
Central	60,730	$ 1,014.18	$1.67	....	....
Lake Superior	198,419	5,859.90	2.95	....	....
Eastern	192,622	6,622.14	3.44	....	....
Atlantic	134,762	3,706.34	2.75	....	....
Total	586,533	$17,203.06	$2.94	$11,647.90	$1.98

Average of 58,000 miles subsequent to removal of superheater:

Division.	Mileage.	Running Repairs.	Per Mile.	Shop Repairs.	Per Mile.
Central	13,433	$ 388.20	$2.89	....	....
Western	2,529	291.50	11.50	....	....
Pacific	44,243	3,931.06	8.88	....	....
Lake Superior	300,660	9,098.92	3.03	....	....
Eastern	632,870	23,341.05	3.69	....	....
Atlantic	238,080	7,919.75	3.33	....	....
Total	1,231,815	$44,970.48	$3.65	$34,842.28	$2.83

It will be seen that the cost previous to the removal of the superheaters was less than afterward. This is due to the engines being new and requiring but little other repairs, but it shows that slight error would be made in taking the mileage and cost since new. This, which is the total of the two previous results, is as follows:

Division.	Mileage.	Running Repairs.	Per Mile.	Shop Repairs.	Per Mile.
Central	74,163	$ 1,402.38	$1.89	....	....
Lake Superior	499,079	14,958.82	2.00	....	....
Pacific	44,243	9,098.92	8.88	....	....
Western	2,529	291.50	11.50	....	....
Eastern	825,492	29,963.19	3.64	....	....
Atlantic	372,842	11,626.09	3.12	....	....
Total	1,817,948	$62,173.04	$3.42	$46,490.18	$2.55

Noting the large mileage made by the M-4a on the Pacific Division, and also the fact that a large amount of the mileage was made in the West, whereas the M-4b made 90 per cent of their mileage in the East, where the general cost of repairs is about 20 to 25 per cent lower, there is no doubt that the M-4a have not cost any more for repairs than the M-4b, and this is a good demonstration that the cost of maintenance is not seriously affected. While not comparable with the simple engines the results on the D-10 engines since their introduction about eighteen months ago are interesting, as showing a comparison between the D-10a, b and c with "Schmidt," "Cole" and "Vaughan-Horsey" superheaters respectively. The figures are as follows:

Average of ten D-10a engines:

Division.	Mileage.	Running Repairs.	Per Mile.	Shop Repairs.	Per Mile.
Central	317,799	$ 9,969.47	$3.14	....	....
Western	460,080	19,654.48	4.27	....	....
Total.	777,879	$29,623.95	$3.81	$15,153.62	$1.95

Average of three D-10b engines:

Central	1,763,830	$82,818.82	$4.70	....	....
Western	31,856	2,092.01	6.57	....	....
Lake Superior ..	88,802	2,580.32	2.91	....	....
Total.	1,884,488	$87,491.15	$4.64	$49,249.26	$2.61

Average of ten D-10c engines:

Division.	Mileage.	Running Repairs.	Per Mile.	Shop Repairs.	Per Mile.
Central	272,926	$11,650.04	$4.27	....	....
Lake Superior ..	423,973	11,819.45	2.79	....	....
Eastern.	68,557	1,994.26	2.91	....	....
Total.	765,456	$25,463.75	$3.32	$15,500.11	$2.02

The average mileage per engine is 77,788 for the D-10a, 62,616 for the D-10b and 76,545 for the D-10c, which averages about 4,000 miles per month for these engines, and it will be seen that the D-10a and c show from 3.32 to 3.81 per mile for running repairs, when the D-10b are 4.64, and a corresponding difference in shop repairs. This difference is due to the cost of keeping the headers tight and explains to a great extent the cost developed on other roads.

LUBRICATION.

The idea that forced feed lubrication was necessary with superheated steam proved to be entirely wrong. It is true that insufficient oil produces bad results more quickly with superheated than with saturated steam, but the sight-feed lubricator is equally as satisfactory with the former as with the latter and, in fact, rather better on account of the drop in pressure on account of the steam being wire-drawn in passing through the superheater. Satisfactory results are obtained with one feed to the valve chest branching into the bushing at each end of the valve, although on the Canadian Pacific one feed is used to each end of each valve. A separate feed to the cylinder is necessary, at any rate, with the quality of oil at present employed, and experiments are necessary with other grades of oil before stating what will finally be required. With good lubrication at present there is a rather faster wear of piston and valve packing rings with superheated than with saturated steam, but the difference is not serious.

H. H. VAUGHAN (Chairman),
LE GRAND PARISH,
C. A. SELEY,
Committee.

MONTREAL, CAN., May 29, 1907.

MR. VAUGHAN: Since writing the paper I have come to the conclusion from some facts we have learned about overheating of return bends, that the neglect of dampers has a good deal to do with the stopping up in the tubes. I do not believe the cinders will attach themselves to a cool return bend, and they do attach themselves very readily to a very hot one. We are not sure of that, but we think that is the solution.

I might say that a point has come up which I think is pointed out in the paper somewhere, but I have omitted to speak of it, that is, that there is a drop of pressure of from five to seven pounds under ordinary working conditions in the steam passing through the superheater. That makes the sight-feed lubricator a better lubricator on a superheater than it is on a saturated steam engine. As a matter of fact, on account of our always having seven pounds or more difference between the boiler and steam chest in the superheater than in the ordinary simple engine, the sight-feed lubricator worked just that much better instead of worse, and there is less trouble with it than there is on the ordinary engine.

C. A. SELEY (C. R. I. & P. Ry.): Mr. President, the table on

page 2 shows the Rock Island has the largest number of superheating engines of any road outside of the Canadian Pacific. I might say in a general way that our faith in the superheater has been increased rather than diminished by the experience we have had. These engines were built with the Field tube. We did have a great deal of trouble with the ends of the tubes being stopped up by a very hard deposit that adhered in such a way that it was very destructive in its removal of tubes and bearers at the end. With one engine changed to a return tube arrangement within the last few months we have apparently done away with all those troubles. I think the explanation in the paper is correct, that the end of the tube is a dead end largely. With the Field tube extreme care must be used in running the inner tube very close to the end, and we found that was not the practice of the builders, in using as much care as should have been. We are expecting to change the remainder of our engines to the return bend system, with the same satisfaction as on the engines already changed. These are in heavy passenger service and they will do better than the non-superheating engines. Our experience in the matter of lubrication is entirely in line with the last paragraph.

The President: I doubt if there is anything before the American railroads that is of more vital importance than this question. The paper is a most excellent one and should result in creating a great deal of interest on the subject of superheaters for locomotives. Is Mr. Bartlett here, of the B. & M.? Mr. Pratt, have you any experience to report?

E. W. Pratt (C. & N.-W. Ry.): I can not give you that information, Mr. President, but I would like to move that when the discussion is closed, the committee be continued, with the hearty thanks of this Association for their paper and the work connected with it.

Mr. Vaughan: This question of superheating is developing rather peculiarly. We are in it very heavily. At the end of this year we shall have about 375 engines equipped with superheaters, all big engines; and in the States, while there have been a few spasmodic instances, nothing at all has been done on any extended scale. In my opinion the roads in the States have done very wisely. We have had a great deal of trouble in our experimental

work with superheaters. I do not think we have lost money on it, we have made money on it, but we have had a lot of things to find out. Superheating came to this country with no experience except the European practice, and what does for European practice will not always do for us. That may be illustrated by a thing we have had driven on to us, and that is, that whatever superheater you use you have to use one that can be fixed up in an hour or two and the engine put back into business. I do not want to take the position of trying to advertise our own goods, but we have the three superheaters, the Schmidt, the Cole and our own. We got ours up very largely with the idea of providing something different, but we did meet the idea of making each superheating pipe separately and individually connected to the headers. The consequence is we have had engines equipped with Schmidt and Cole superheaters in the roundhouses for a month, practically in and out, trying to get them tight, and with expert men on them too, who are used to setting them up, while with our own type it is never a matter of over two or three hours' delay. The Cole superheaters are good, there is nothing wrong with them except the header joints, but those header joints have given us enough trouble to have condemned the superheater business altogether if we had nothing else to go to, and I think that has been the position in the States very largely, for the roads have tried a superheater that has given trouble, and they have said to a certain extent that the superheater would not do, that it gave them too much trouble. Now, if this superheater can be properly handled it will not give you too much trouble. I believe inside of another year's experience we can say definitely and reliably that you can equip your engine with superheaters, and if you will give them attention, not expense but attention, you can run without any more trouble than you have with the ordinary simple engine. I would like to emphasize the difference between attention and expense. If a device is put on an engine and when an engine comes in and a damper packing is leaking, and a man goes to work and sticks a gasket in the joint, and the roundhouse foreman sees the damper is not working, and lets it go, and then your flame is going through your tubes, and they deteriorate at the return bend, and then you blow off a return bend, and take down the headers and cut the engine out of service, and the transportation department

says, as I heard one man say, "We call them freezers, not superheaters," — that all comes from lack of attention. It would not have cost 5 cents to have replaced that packing right in the first place. If we are going to give up a device that will save from ten to twenty per cent on coal just because we can not get roundhouse machinists and foremen to pay attention to things, we are going on the wrong track. It is a question of attention with your superheaters, and not of expense. We have the records from passenger service of the number of failures, and of these failures a large number came from the use of bronze nuts. There are only three failures that are serious in 198,000 miles. That shows definitely, I think, that you do not have enough engine failures with superheaters to condemn them. Our repair costs show that we do not have enough additional cost of repairs to condemn them. The road records show that they do make a satisfactory saving in coal. Therefore I think this superheating is a thing that is worthy of careful attention and should be taken up properly.

I would like to call one more point to your attention. We frequently hear it stated that our coal only costs us $1.50 or so and it is hardly worth our while to go to the superheating, almost always forgetting that coal that costs $1.50 originally may not cost $1.50 where it is burned. It costs money to haul coal to the place where it is burned. There are many roads showing coal at $1.50 on the performance sheets that are hauling it three and four hundred miles before it is used. You can not haul it much under ½ cent per ton per mile and that runs up very quickly, and there are very few roads that can not afford to spend $800 or $1,000 on a new engine to save that.

W. G. Menzel (Wis. Cent. Ry.): Mr. President, I have been somewhat interested in superheating, but do not think I have ever observed that it has been applied to low pressure. Some time ago in Chicago I met an engineer who was running a superheated engine. I asked him how this engine performed. He said, "Very well, at times." He told me then that the engine was supposed to carry 200 pounds of steam, which was a very poor steamer. He said he never saw an engine that did as good work with 100 pounds of steam as this engine did. The thought struck me at the time that perhaps those who are experimenting with super-

heating on locomotives are making a mistake by trying it on the high-pressure engine; that perhaps the greatest benefit will be derived if a low pressure were used. I know in stationary practice that excellent results are being obtained from superheating. I also know that the repairs of a boiler are less on low pressure locomotives than on high pressure. Now, if we can get results from superheating on the low pressure and discontinue the use of the high pressure, I believe there is going to be a saving both in repairs and in fuel. I would like to ask Mr. Vaughan if he knows of any experiments that have been made on locomotive superheating with low pressure.

MR. VAUGHAN: The Atchison have a superheater applied, which I believe they are working at 130 or 140 pounds pressure. They took one of their compounds and took off the high-pressure cylinders. I think that also applies to a certain extent to the Pittsburgh, Shawmut & Northern engines. The pressure is low, about 160 I think. Since going to superheating we have reduced the pressure on all our new engines to 180 pounds, increasing the size of cylinders in proportion, and so far as we can see, with equally satisfactory results. We are going to derive the benefit from decreased boiler troubles, and get the same economy, and just as lively an engine. The lighter weight of the superheated steam makes the engine just as lively with 175 pounds as the saturated steam at 200, a little better I think.

A. W. GIBBS (Penna.): Could Mr. Vaughan tell us whether the German recommendations for the sizes of piston valves hold out in our practice. I remember when Herr Garbe was over here he mentioned exceedingly small piston valves of special construction to prevent warping. Will they hold out, or do we have to use valves as large as with saturated steam, and do we have to use forced lubrication?

MR. VAUGHAN: We have one engine equipped with the Schmidt valve, a 6-inch valve and an 18-inch cylinder, double-ported valve. We have not followed out that practice any further. It was Mr. Schmidt's design and was more or less complicated on account of the extraordinary precautions that he stated had to be taken to use superheated steam. Since that time we have been using superheated steam in an ordinary engine of the regular

design, but we have used rather smaller piston valves than most people. We use a 11-inch piston valve for a 21-inch cylinder, and we have since enlarged that cylinder to 22½ inches and still use the 11-inch valve, with results entirely satisfactory. I have had a sort of feeling, though, that we have gone about as far as is necessary in putting an 11-inch valve on a 22½-inch cylinder. Of course that is a considerably smaller valve than you would use in general practice with saturated steam. Forced lubrication I do not believe to be necessary at all. I think the sight-feed lubricator, as I said, works better on a superheated engine than on a saturated engine.

THE PRESIDENT: You heard Mr. Pratt's motion that this discussion be closed and the committee be continued, and that we extend the thanks of the Association to the committee for the good work they have done, and hope they will do better next year — I will put that in. [Laughter.]

(The motion was carried.)

THE SECRETARY: I beg to announce the following communication received from Mr. Ross Taylor, President of the Automatic Ventilator Company:

June 13, 1907.

Mr. William McIntosh, Atlantic City:

DEAR MR. MCINTOSH,—Agreeable to conversation this evening, will you kindly have it announced at to-morrow's session that members of the Master Mechanics and Master Car Builders' Associations are invited to take a special train to Philadelphia at 10 A.M. on Saturday, Jersey Central and Reading, arriving on return after luncheon at 2:10 P.M.

Also the following:

ATLANTIC CITY, N. J., June 14, 1907.

President of the American Railway Master Mechanics' Association:

DEAR SIR,— The Baldwin Locomotive Works have great pleasure in inviting the members of the American Railway Master Mechanics' Association and their wives to visit their works in Philadelphia on Saturday, June 15.

The Pennsylvania Railroad has very kindly arranged to run a special train to Philadelphia. This train will leave the Pennsylvania depot at 9:30 A. M. Carriages will meet the train in Philadelphia to convey the members and their guests to the Baldwin Works, where luncheon will be served.

The return train will leave Broad Street Station at 2:28 P.M.

Those desiring to accept this invitation, who are entitled to free transportation, are requested to make application to Mr. J. W. Taylor as promptly as possible.

It will be necessary, therefore, for those not entitled to free transportation under the present ruling of the Interstate Commerce Commission, to provide themselves with the usual railroad ticket.

Yours very truly,

BURNHAM, WILLIAMS & CO.

The Auditing Committee reports as follows:

June 13, 1907.

Your committee appointed to audit the books and vouchers of the Secretary and Treasurer begs leave to report that the accounts and vouchers have been examined and found correct, corresponding with the report of the Treasurer. Respectfully submitted,

O. H. REYNOLDS,
R. PRESTON,
L. R. POMEROY,
Committee.

(On motion of Mr. Peter H. Peck (C. & W. I. & Belt) the report of the Auditing Committee was received.)

PRESIDENT DEEMS: The next paper is "A Blank Form to Give the History of Locomotive Movements at Terminals," Mr. G. M. Basford.

The paper is as follows:

REPORT OF COMMITTEE ON A BLANK FORM TO GIVE THE HISTORY OF LOCOMOTIVE MOVEMENTS AT TERMINALS.

To the Members of the
American Railway Master Mechanics' Association:

Coöperation between the mechanical and operating departments is always necessary, but it becomes vital during periods of congestion or when, for any reason, power is in great demand.

Your committee was instructed to propose a blank form for use at terminals, to give the history of the movement and time of every locomotive from the time of leaving a train until it takes another, the object being to secure closer coöperation between the mechanical and operating departments.

With this in view, a joint blank is submitted, which is arranged in such a way as to necessitate coöperation in the record itself by rendering

it necessary for each department to fill in the items, the control of which lies in its own hands. In this way each department may become conversant with the delays and the reasons for delays for which both departments are responsible.

It is recommended that the roundhouse and the yard shall use the same form, one for each twenty-four hours. Both the roundhouse and the yard should make its own entries in duplicate — an original and a carbon copy. Immediately at the close of the day, after midnight, the carbon copies may be exchanged and the record completed on each original copy. If sufficient force is available, the records may be combined or completed by a third party. By such a plan close coöperation may be expected, because the local head of each of these departments will, at all times, see that his own record is but part of the whole. Each of the officials will also see where his work fits into that of the other.

In the blank proposed, columns A to F, inclusive, indicate train and engine numbers, the name of the engineer and the time of arrival at the yard, the ash pit and the roundhouse.

If necessary, columns may be added to indicate whether the engine is in freight, passenger, switch or work service; but these are not recommended by your committee for use where they are not necessary.

Column G will show the time when orders for engines are received. This information may be important in checking the work of the roundhouse. Column H shows the time engines are promised, and column I when they are actually ready.

Columns J and K show the number and leaving time of trains for which engines are ordered. Columns L, M and N show when engines leave the roundhouse, when they arrive in the yard and when they are coupled to trains.

Columns O, P and Q indicate the number and time of the departing train; also the name of the engineer.

In the remaining columns the delays, both mechanical and transportation, are indicated together with the reasons therefor.

On roads where clerical force is not available it may be desirable to have enginemen supply information for columns A, B, C, D, E, F, L, M and N. For this purpose a small blank form is presented — merely as a suggestion — as a part of this report. One form may be used for arrival as well as departure. For the arrival record the engineer should fill out columns R, S, T, U, V and W. For departure he should fill out Columns R, S, T, X, Y and Z. Upon arriving at the ash pit on an incoming engine he should send the blank to the roundhouse, and upon coupling to an outgoing train he should leave another blank with the yardmaster. This information may then be easily transferred to either the roundhouse or the yard record, depending upon whether the engine is arriving or departing.

Your committee submits the record form with the recommendation that it be tried experimentally for a year by as many railroads as possible,

with a view of gaining opinions from experience upon which to base further action of the Association upon this subject. Your committee also suggests the advisability of securing the opinions of leading operating officials concerning such a blank form, whether or not these officials have an opportunity to put it into service.

It is also suggested that during periods of congestion an energetic man be placed at each locomotive terminal to follow up locomotive delays by aid of this form.

The blank form recommended herein should be understood as offering means for accelerating movements of locomotives when locomotives are greatly needed. Unless acceleration is especially desired, it seems inadvisable to stimulate action on the part of roundhouse forces to hurry the handling, inspection and, more especially, the repair work when there is ample opportunity to take sufficient time to improve the quality of maintenance and inspection and at the same time economize in the cost by eliminating overtime and other irregular work for which a premium must be paid. Your committee does not desire to recommend the continuous use of this blank form, except in cases where it may be necessary to increase the activity of terminal operations. Its occasional use to check locomotive service may, however, be exceedingly valuable.

The tendency toward placing an unnecessary burden by exacting unnecessary conditions from either the transportation or the locomotive department should be discouraged. One purpose of this blank form is to enable each department to help the other. It should not be the desire of either the Motive Power or the Transportation department to show the other department that its own work is done and lies waiting. While such a case frequently brings about the desired result, it is an expensive matter for either department to carry on its work in such a way for the purpose of unnecessarily stimulating action on the part of another department.

In conclusion, your committee would point out the importance of introducing this form in service with a complete understanding on the part of all concerned that the necessary requirement is to reduce delays; that the purpose is to secure smooth, quick service; and that the blank is in no way intended as a means for placing responsibility upon another department. If each department will use it to improve its own performance, the desired result will be attained.

Respectfully submitted,

G. M. Basford (Chairman),
H. M. Carson,
C. E. Chambers,
T. Rumney,
J. E. Muhlfeld,
Committee.

New York city, April 24, 1907.

Mr. G. M. Basford (American Locomotive Co.): Your committee realizes the impossibility of recommending a blank form or use at terminals which will meet all conditions, but has made in attempt to suggest a form which may be more or less elastic ınd adaptable to various conditions. The report is accompanied y a suggestion that this form be tried with a view of securing ecords of experience at the convention of next year.

The underlying idea in the report is coöperation between the nechanical and the operating departments in the prompt movenent of locomotives at terminals. With this in view a joint blank s suggested, the roundhouse forces and the other forces to use he same blank, each one filling in its own portion, the idea being hat the two departments will then see that each has its part to erform and that its part fits into that of the other department.

There are two blanks in the report, the larger one is divided nto several parts, beginning with columns under the heading 'Arriving." These give, "Train No., Engine No., Engineer's name, Time in Yard, Time in Ashpit — and concerning that column, "E," Time in Ashpit, it has already been suggested by one of the members of the committee that possibly a different heading may be required in case it may be necessary for the engineer to give up his engine beyond the ashpit, at the coal chute, or some other point. That heading may be changed easily to 'On Enginehouse Track," or any other suitable one. Following hat heading is, "Time at Roundhouse." Following these are hree columns, G, H and I, indicating "Time Order Received," Time Promised" and "Time Ready." I think further explanaion is not necessary except to say that it may at times be valuable o know when an engine was ordered, when it was promised to e ready and when it was actually ready, in order to check up the vork of the roundhouse.

Following are two columns indicating the train number for which the engine was ordered and the time. Following are three columns under the head of "Departing" for the time when the engine left the roundhouse, arrived in the yard, and was coupled to the train. Following this are two columns, one for the train number, and the other for the time of departure, and then there is a column for the engineer's name, and the blank is completed

by columns indicating mechanical delays and transportation delays.

The report itself explains the way that this information may be obtained, columns A to F are expected to be filled out from information given by the engineer, requiring no clerical work except in the final record. The engineer may use a small blank (attached to the report), giving this information. The roundhouse force fills out the columns G, H and I, and also J and K. Engineers in departing will leave at the yardmaster's office another of these small blanks in which the information or columns L, M and N are included. The small blank is intended merely as a convenience in securing information and getting it quickly.

The report suggests that the operating department, in this case, the yardmaster's office, should have one of these complete reports, and that the roundhouse forces should have another, the two being exactly alike. Each may then put in its record in an original and a carbon copy, and at the close of the day transfer the carbon copy to the other department. From the carbon copies each of the blanks may then be completed by the operating and mechanical departments, so that the delay of each shows in connection with the delay of the other. The idea of the committee was that possibly by this arrangement there might be some reduction of delays by making a much closer coöperation.

In conclusion, your committee would point out the importance of introducing this form in service with a complete understanding on the part of all concerned that the necessary requirement is to reduce delay; that the purpose is to secure smooth, quick service; that the blank is in no way intended as a means for placing responsibility on another department. If each department will use it to improve its own performance, the desired result will be attained.

Mr. P. H. Peck (C. & W. I.): This system may be all right where one road only has a terminal. I have the engines of five roads at our terminal, and am handling about 100 engines a day. We report the engines to the roads when they are ready for use. Sometimes they want more engines than we have at the terminals, and we have to call for a relay of engines to be delivered from outside the terminal. If we undertook to follow out the blank as

presented by the committee, it would entail upon us an endless amount of work. In our case we merely report the movement of engines which we have ready for service.

MR. F. H. CLARK (C. B. & Q.): We use a similar report, and have had it in service for a couple of years. We have found it very serviceable at times in locating delays to power. You occasionally find conditions such that quick turning is necessary, and in a case of that sort I think such a blank has a great many advantages.

MR. G. M. BASFORD: May I add to my remarks in introducing the report, the statement that the report itself shows that it is not intended or recommended by the committee for continuous use. It is intended for use at times when power is very greatly needed, and when its use will save time. One of the members of the committee, however, desired the report to be changed in this respect to show that it was advisable to use the system all the time in order to accelerate the movement of locomotives at all times.

MR. LEGRAND PARISH (L. S. & M. S. Ry.): We have a blank for similar use and it has given good results, and we feel from our experience that it would pay us to continue its use throughout the year.

CHAIRMAN MCINTOSH: If there is no further discussion on this subject we will proceed to the next paper.

MR. H. H. VAUGHAN (Can. Pac. Ry.): I would ask Mr. Basford whether he means by mechanical delay the time the engine is received on the ashpit until it is ready, including all the time the engine is at the roundhouse as a delay?

MR. BASFORD: The committee had not that idea in mind. The time the locomotive is at a terminal may be divided into two parts, necessary time and unnecessary time. The committee expected this column to include explanations or excuses, or whatever may be necessary under the circumstances to cover the differences between the time promised and the time ready, to indicate unexpected delays, or any delays that should not have occurred. It is not the intention of the committee to suggest this mechanical delay as covering all the time at the terminals by any means; a

certain time is necessary, but only that time or delay which is unavoidable and is occasioned by mismanagement or accident.

MR. VAUGHAN: I do not agree with the committee then. My experience is this — the same blanks would be used as telegraph blanks are used, which latter are only used at busy times. The regular blank is handled all the time, because we are getting our accounting department, which makes up the mileage statement by divisions from the superintendent's reports, to try to give us figures showing the time each engine was in the house and the average miles per hour which the engine makes between the time it leaves the house and the time it comes back to it. Some of the miles per hour do not amount to much and can be improved. If you can get a figure level throughout the year, and showing the miles per hour you work through freight engines, you will find some great differences between different divisions. We, like a lot of other roads, always had reports from the mechanical department showing whether an engine was delayed on account of the mechanical department, or on account of the traffic department. We used to get reports showing that eight or nine engines were ready and were not called for, and then, of course, we would write to the superintendent and tell him that he was not handling the trains right; that there were so many engines ready which were not being used, and that the roundhouse was ahead of them. As a matter of fact, in busy times the yardman can go in and give the roundhouse a bunch of orders which will keep it going for a week, and there is no defense possible on the part of the roundhouse; it is an absolutely defenseless proposition. The only way to do is to take the total time at the roundhouse, and charge it up to the mechanical department, not worry as to who is responsible for it; simply saying we are losing five or six hours, we will say, as an average, at a terminal, and if we get up to an average of eight hours, we had better look into it. I think the mechanical delay should be computed from the time the engine is received at the ashpit until it is ready for the train, because when there is a transportation delay, at that time you do not need the power. When you do need the power, there are no transportation delays unless it is due to the roundhouse foreman's way of figuring with the yard. It is all mechanical. They will take the locomotives generally as fast as you can give them.

If we should use this blank, I would like to make the mechanical delay to represent the time during which the engine is at the roundhouse until it is ready at the terminal and base the number of hours on the average of that.

MR. E. A. MILLER (N. Y. C. & St. L. R. R.): For the last three or four years we have used a blank much simpler in my mind than the one presented by the committee, showing the time of the arrival of the locomotive on the roundhouse track, the time when it was ready for service, the time that it is held after being ready for service until ordered. This blank is used between the roundhouse foreman and the yardmaster. It has been of great advantage to us and has worked very well. We use it all the year around and are able to detect quickly any unnecessary delays, whether from the failure of the yardmaster to order power promptly, or failure in handling the engines promptly by enginehouse men.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): We have found it advantageous, during seasons of heavy business and shortage of power, to use a blank gotten up largely on the same lines, and it invariably showed up some weak points and some places where an improvement could be immediately applied, but the greatest benefit we have derived from the use of a blank of this kind is to show that there were terminal restrictions, clinker-pit restrictions, a shortage of capacity of coaling plants, not sufficient track room, to handle and pass the engines as they were coming and going, and the blank has been of greater benefit to us in bringing the difficulties and shortcomings vividly before the management, and enabling us to get an appropriation to secure accommodations which we really required.

I have in mind several terminals where we resorted to the use of the blank, and while it did not very materially quicken the movement of the power at that time, it did put the terminals later on in such condition that to use the words of one of the managers in regard to the matter, "after that was done, the terminal looked like Sunday all the time."

MR. G. W. WILDIN (L. V. R. R.): The Lehigh Valley R. R. uses a form which is enough like the blank proposed by the committee to cause one to think the latter was probably copied from

it. We do not use the form the year round. My experience is when summertime comes and everything is going smoothly, reports of this kind are not looked over very thoroughly, and they entail a great deal of clerical work at terminals which can be eliminated during the dull season or when locomotives are plentiful.

I think as Mr. Vaughan does, that all the terminal delays should be charged to the mechanical department, from the time the engineer delivers the engine to the mechanical department until the time it is delivered back to the transportation department. If this form is to be put into effect, I think the column headed "Cause" should be probably as large as the remainder of the sheet, so a full explanation can be made.

Mr. A. W. Gibbs (P. R. R.): I do not think Mr. Vaughan said that. I understood him that he wanted to charge the whole time from the arrival of the locomotive until the train left to the Motive Power Department. I think you smother up then the delays that enable you to make calls for the power you need.

Mr. H. H. Vaughan: Not until the train left, but until the engine was delivered to the train.

Mr. Gibbs: I understood you said until it left.

Mr. Vaughan: Until it left the roundhouse.

Mr. C. E. Chambers (C. R. R. of N. J.): I do not know whether Mr. Vaughan means that the mechanical delay would be charged against the engine until it reaches the yard or the time reported ready to the transportation department, as being ready for service.

Mr. Vaughan: My idea would be the time when ready, because there is a column here headed "Ready."

Mr. Chambers: The point is it might be reported ready to the transportation department, and not ordered for two or three hours.

Mr. Vaughan: My idea is when that happens you do not care whether you have a form or not. The time when that happens is when there is no business. The time you want the form for is when the transportation department can give you more orders than you can furnish.

Mr. Chambers: As a matter of fact, it does happen many times when you have lots of business, the engines come in in bunches, for which you are not responsible, and we may get them ready in bunches, and the transportation department could not use them, and that delay is up to the transportation department.

Mr. G. W. Wildin: I think under the column "Cause" the roundhouse or mechanical department could protect themselves by putting in the cause.

Mr. G. W. West (N. Y. O. & W. Ry.): Why should the mechanical department be put on the defensive in every case?

P. H. Peck (C. & W. I. R. R.): It is only when business is rushing that complaints are made to the mechanical department about delays to engines. Other times there are plenty of engines and when they are not rushed the blame of delays at roundhouses can be avoided. When business is rushing, five, six or eight engines may come in together, and as you know the terminals are full of cars you hurry to get the engines ready to go out again as soon as possible. You find they are not called for and you inquire and they tell you the train crews are taking a rest — have been out too many hours, while if they had notified the mechanical department of this when the engines came in, much more and better work could have been done on the engines than when you expected them to be called for at any moment. The mechanical department is blamed for almost every delay to engines or cars, but it seems as if there is no remedy for it and it has always been that way.

The President: We will now take up the individual paper on "Locomotive Failures, Records and Results of Keeping Them." This paper was prepared by Mr. W. Dunham, of the C. & N.-W. Ry. Co., and will be read by Mr. E. W. Pratt, of the same company.

Mr. Pratt presented the paper as follows:

LOCOMOTIVE FAILURES, RECORDS, AND RESULTS OF KEEPING THEM.

By MR. W. E. DUNHAM, M. M., C. & N.-W. Ry.

To the Members:

The failure of an engine in service interests so many of the various departments of a railroad directly or indirectly, as well as the traveling or shipping public, that every energy is bent toward avoiding them. Shortage of power at times may compel the use of engines on the road which, under ordinary circumstances, would be held for back-shop repairs. These engines, then, should not be expected to handle full tonnage, but should be favored to a degree decided upon by the Master Mechanic in charge. But, on the other hand, no engine should be permitted to start on a trip unless the roundhouse foreman is sure, to the best of his knowledge, that the engine will make the trip successfully if it is handled properly and is not delayed unreasonably. And too, an engine crew should be given as much consideration as we do our engines. They can not work perpetually on short hours of rest unless their working hours are made short.

It is natural during a rush period, whether of long or short duration, that engine failures increase in number and often also in proportion to the total miles run in a given period of time. These results may be due more to the operating methods and conditions than to any lack of attention on the part of the roundhouse forces. Under these circumstances the division as a whole should stand the results, instead of the motive power department only being charged with a failure.

There exists at the present time on American railways no uniform method of recording engine failures. This is due to several causes, chief among which is the fact that what would be considered as an engine failure on one road would not be on another. A complete file of what constitutes engine failures would contain as many definitions, almost, as there are railroads. And they would be from "whatever the operating department charges," to "all delays on account of waiting for an engine at an initial terminal, engine breaking down, running hot, not steaming well, or having to reduce tonnage on account of defective engine, making a delay at a terminal, a meeting point, a junction connection or delaying other traffic." In some cases made-up time would eliminate the delayed time and a failure would not be charged. In other cases a delay of two minutes on a passenger train or five minutes on a freight train at any point on the division would be an engine failure.

A failure is the result of ineffectual efforts to accomplish a desired end. The desires of the railway train service are; to keep all trains moving promptly; to leave the starting terminal on time; to make all meeting points; to make all junction connections; to avoid delays to other trains, and reach the destination on time. A failure should therefore

be charged to an engine when through some fault of the roundhouse, the engine or the engine crew the train fails to meet these expectations. But let us suppose that a delay does occur as the result of a defect in the engine, but at the same time all meeting points and junction connections are made and the train departs and arrives on time. Should a failure be charged? Would not a record of a delay answer all the purposes? An engineman hates to be responsible for a failure, but he takes pride in being able to make up for all delays for which he or his engine are the cause.

Any set of rules for making engine failure records should be lenient, in a measure, to both the mechanical and transportation branches of the operating department. Reasonable leeway should be given on both sides. Experience is the best guide as to how much this leeway should be and experience also is the best guide as to what an engine should be charged with. Considering all parties directly interested a fair statement of what constitutes an engine failure might be as follows:

First. A delay waiting for an engine at an initial terminal constitutes an engine failure, excepting in cases where an engine has to be turned and does not arrive in time to be dispatched and cared for before leaving time.

Second. A delay at a terminal, a meeting point, a junction connection, or to other traffic, or a reduction of tonnage due to an engine breaking down, not steaming well, running hot or any defect in the engine constitutes an engine failure.

Under these rules the following can, with justice to all concerned, be considered as not constituting engine failures:

1. Delays to passenger trains when they are five minutes or less late at terminals or junction points.

2. Delays to scheduled freight trains when they are twenty minutes or less late at terminals or junction points.

3. Delays to extra dead freight trains if the run is made in less hours than the miles divided by ten.

4. Delays to fast schedule trains when the weather conditions are such that it is impossible to make the time, providing the engine is working and steaming well.

5. Delays when an engine loses time but afterward regains it without delay to connections or other traffic.

6. Delays to a passenger or scheduled freight train due to other causes, and the engine (having a defect) makes up more time than she loses on her own account.

7. Delays when an engine is given excess of tonnage and stalls on a hill, providing the engine is working and steaming well.

8. Delays when an engine gets out of coal or water caused by being held between coal or water stations an unreasonable length of time.

9. Delays due to engines steaming poorly or flues leaking on runs where the engine has been held on side tracks other than by defects of

engine, or on the road an unreasonable length of time; say fifteen hours or more per one hundred miles.

10. Reasonable delays for cleaning fires and ash pans on the road.

11. Delays caused by breakage of some part of the engine caused by sticking obstructions on or beside the track.

12. Delays due to broken draft-rigging on engine or tender caused by air being set on the train on account of burst hose or break-in-two.

13. Delays to an engine coming to the shop for repairs when it is hauling full tonnage.

14. Delays caused by an engine being held in the roundhouse for needed repairs and called for by the operating department, although they have been informed that the engine will not be ready until a stated time.

Any system of engine failure reports must start with the advice received from the engineman by the dispatcher. This should include sufficient information so as to show whether the boiler, the machinery or some of the special attachments are troubling, and, if possible, give a brief detail of what is wrong. The dispatcher then should advise the Master Mechanic, or the division foreman and also the road foreman and the local foreman of the terminal toward which the engine is headed. Upon the arrival of the engine the roundhouse foreman or his representative should make a personal and close examination and prepare a statement, which he forwards to the Master Mechanic along with the engineman's written explanation. These papers will give the Master Mechanic full knowledge of the case and they should be in his hands within twenty-four hours after the failure occurs. This prompt action is of particular value in connection with failure reports, convincing all concerned that things are being watched and checked closely.

With a view to having uniformity in their reports and saving time the blank breakage report forms, printed in copying-ink, as shown by figures in the last pages of the paper, can be used. These reports should first be checked by the local Master Mechanic and shop foreman and then passed on to the assistant superintendent of motive power, who in turn sends them to the mechanical engineer for final checking and filing.

Upon the accuracy and detail of these first papers depends the full value of the failure records. As a further check upon the work performed by the engine, a delay report can be made out by the engineman for each trip. An outline of this form is shown. Frequently by following back a few days and noting the performance of the engine as shown by these reports the real cause for the final failure can be found. A good supplementary report in this same connection is one of a similar character made by the conductor to the division superintendent.

After a full examination and investigation of each failure a monthly division report should be made by the Master Mechanic to the superintendent of motive power. A more frequent report of this kind is often advisable, for instance, once every ten days. These reports can then be

compiled in the superintendent's office, a statement being made which classifies and details the failures and also shows totals for each division or terminal of the railway.

Any system of reporting engine failures should have for its sole aim the improvement of the service by giving information as to what is causing trouble. This requires accuracy, as previously mentioned. There is a natural tendency for enginemen to be rather cautious about sending telegraph reports of defects or troubles on snap judgment as well as a similar tendency for a dispatcher to be inclined to blame the engineman or the engine for being the primary cause of a train delay. These active representatives of two branches of the operating department are the men who can do the most toward reducing engine failures by keeping in close touch with each other when on duty and by giving all the facts in a plain and full manner when trouble does occur. If the failure is due to long hours on the road the information is of value to the superintendent, who can determine the necessary action for increasing the speed of the train or trains. From these same records his attention is forcibly brought to the results of inferior coal, poorly designed and operated coaling stations, scanty and bad water supplies, overloading of engines, indifferent train-dispatching, lack of harmony in action on the part of the men in charge of the trains.

To the mechanical department officers these reports are particularly valuable. In connection with the same records made by the shops, they show up poor designs, weak parts, inferior material, bad shop practices, careless handling, indifferent inspection and poor workmanship. The local Master Mechanic and shop foreman make the first use of these reports as they receive them. Inspection of the broken or defective part, together with the report of what occurred, gives them the best possible line-up as to what is necessary to prevent a repetition. Their investigation should be carried to a finish and the exact cause found.

The full report then goes to the next higher officer, usually the assistant superintendent of motive power. Here it is checked and by the frequency of similar reports, attention is drawn to some particular defect. It may be some type of cylinder head, rod strap, eccentric or any such part of the machinery of a certain class of engine that is giving particular trouble. Or it may be a certain make of boiler will not stand up to the service. These reports quickly show these defects to those who are in charge of such matters. The detail can then be quietly and efficiently remedied without the necessity of any further investigation. Such, generally, is the case if some shop or shops are at all careless in preparing the work or are passing as good enough parts that are not true to dimension or shape, or material designated.

When the assistant superintendent of motive power is through with his investigation the reports then should go to the mechanical engineer. He should check the dimensions and shape of the broken piece. As the result of his analysis data are obtained for use in future designs either for new parts

to take the place of defective ones or for preparing plans for new engines. To him it shows up where modern shop practices and road service have found the weak spots in older types of engines. Steps are then taken through the proper channels to discard the troublesome member and substitute as fast as possible a modern design.

Concrete examples of instances where such a system of reports has resulted in improvements to the service and cost records would approximate a complete history of nearly all our modern improvements. Troublesome main frame splice connections brought out the solid through frame; cracked cast-iron cylinder heads were followed in some instances by an improved design, and in others by the use of cast steel; loose guide blocks on account of nuts backing off called for guide blocks cast directly on the cylinder head; front frames bent by hard service or a slight collision gave the idea of a front engine deck with short and stiff frame connection; stuck checks suggested the use of an intermediate valve between the boiler and the check; cracked spokes in the first steel driving wheel centers demanded heavier patterns, even though the first cost was a little high; the inability to quickly and efficiently cool off a hot driving pin was the incentive to develop the use of hard grease; such is also the case with driving journals; cracking and breaking of main frames led to more efficient cross bracing; persistent crack side sheets in boilers with narrow water-legs compelled the use of wider legs and better steam passage conditions; the inaccessibility of the Stephenson link motion on modern large power for oiling purposes is one of the prime factors in developing the Walschaert gear.

There is no doubt as to the merits of such a system of failure reports as outlined, in the minds of those who have followed it carefully and consistently. With our railway systems spread over a large territory and divided up into small sections for operating and mechanical attention it is absolutely necessary that some general procedure as this be followed. For the purposes of comparison also as between different lines it is to be hoped that some standard agreement can be reached for recording and classifying engine failures.

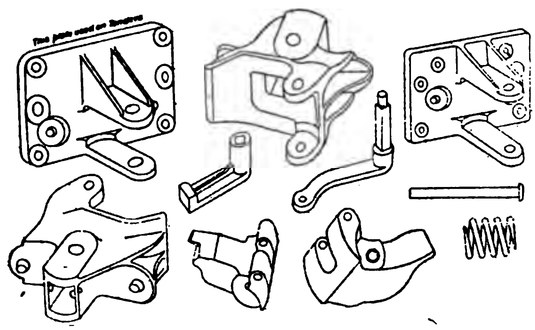
CHICAGO & NORTH WESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

PLATE COUPLER.

Engine No. ______ Date found on inspection ______ 190__
or
Class ______ Date of failure ______ 190__ Reported at ______

Note.—Indicate with red ink location of fracture and give dimensions to some fixed point. Answer the questions below. Send report to Asst. Supt. M. P. & M., Chicago, Ill.



REMARKS.

Kind of metal.

Was there flaw at point of fracture?

Was there an old crack?

Probable cause of failure

______ Master Mechanic

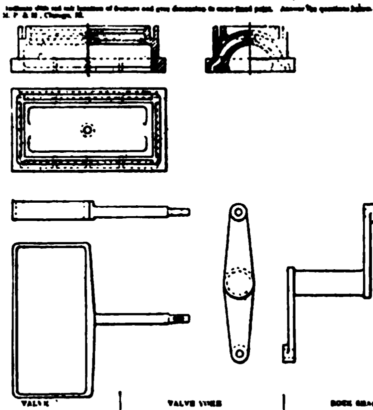
CHICAGO & NORTHWESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS

VALVES, VALVE YOKES AND ROCKER SHAFT.

Engine No. ______ Date found on inspection ______ 190__
or
Class ______ Date of failure ______ 190__ Reported at ______

Note.—Indicate with red ink location of fracture and give dimensions to some fixed point. Answer the questions below. Send report to Asst. Supt. M. P. & M., Chicago, Ill.



VALVE

Pattern No.

Kind of Metal.

Dimensions and, if possible, sketch of section at point of fracture.

Kind of valve.

Kind of balancing.

Was there flaw at point of fracture?

Probable cause of failure.

VALVE YOKE

Kind of metal.

Dimensions and, if possible, sketch of section at point of fracture.

Was there flaw at point of fracture.

Probable cause of failure?

ROCK SHAFT

Pattern No.

Kind of Metal.

Dimensions and, if possible, sketch of section at point of fracture.

Was there flaw at point of fracture?

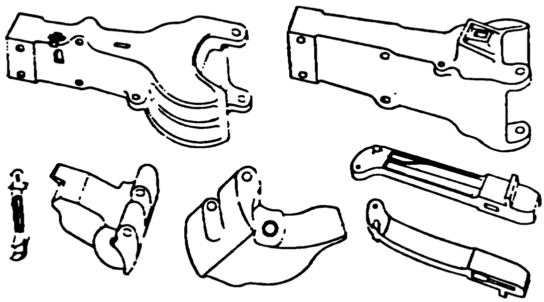
Probable cause of failure?

______ Master Mechanic.

CHICAGO & NORTH WESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS

PILOT COUPLER.



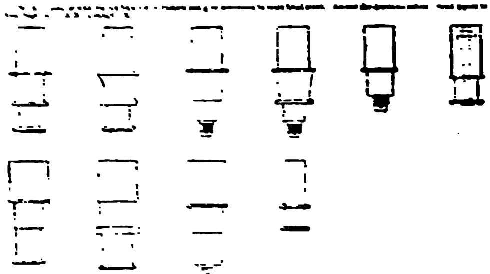
REMARKS.

Master Mechanic.

CHICAGO & NORTHWESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

CRANK PINS.



MAIN PIN	BACK PIN	FRONT PIN.

Probable cause of failure.

Master Mechanic.

Form 600

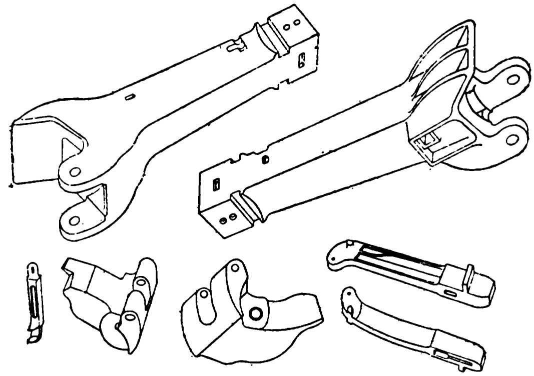
CHICAGO & NORTH WESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

M. C. B. COUPLER.

Engine No.________ Date found on inspection________________190___
or
Class ________ Date of failure ________________190 Reported at ________________

Note. Indicate with red ink location of fracture and give dimensions to some fixed point. Answer the questions below. Send report to Asst. Supt. M. P. & M., Chicago, Ill.



REMARKS.

Kind of metal.

Was there flaw at point of fracture

Was there an old crack

Probable cause of failure

________________ Master Mechanic.

Form

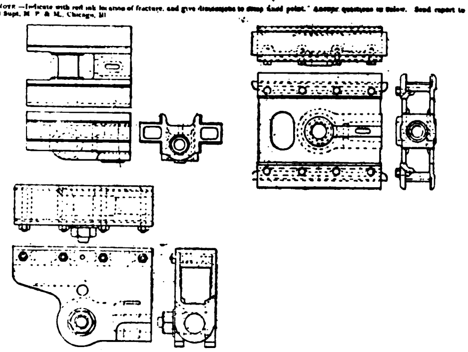
CHICAGO & NORTHWESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

FOUR-BAR CROSSHEAD. LAIRD CROSSHEAD. TWO-BAR CROSSHEAD.

Engine Number,________ Date of failure________________ Reported at ________________ 189

Note.—Indicate with red ink location of fracture, and give dimensions to some fixed point. Answer questions as below. Send report to Ass't Supt. M. P. & M., Chicago, Ill.



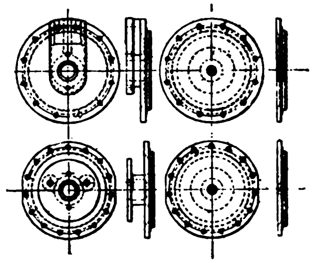
FOUR BAR CROSSHEAD	LAIRD CROSSHEAD	TWO-BAR CROSSHEAD
Pattern No.	Pattern No.	Pattern No.
Kind of Metal	Kind of metal.	Kind of Metal
Dimensions and, if possible, sketch of section at point of fracture	Dimensions and, if possible, sketch of section at point of fracture.	Dimensions and, if possible, sketch of section at point of fracture
Was there flaw at point of fracture?	Was there flaw at point of fracture	Was there flaw at point of fracture?
Probable cause of failure?	Probable cause of failure?	Probable cause of failure?

CHICAGO & NORTHWESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS

CYLINDER HEADS

Engine No ________ { Date found on inspection ________ 190__
or
Class ________ { Date of failure ________ 190 . Reported at ________



BACK HEAD.

Pattern No

Dimensions and, if possible, sketch of section at point of fracture

Kind of metal

Was there flaw at point of fracture?

Probable cause of failure.

FRONT HEAD.

Pattern No

Dimensions and, if possible, sketch of section at point of fracture

Kind of metal

Was there flaw at point of fracture?

Probable cause of failure

Form 801

CHICAGO & NORTH WESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS NOT COVERED BY SPECIAL FORMS.

Engine No________ { Date found on inspection ________ 190____
or
Class________ { Date of failure ________ 190____ Reported at ________

Hauling ________ Section Train No________

REMARKS: ________

____

____

____

____

____

Master Mechanic.

NOTE.—Make sketches of one part only on a sheet, but as many views as may be necessary. Indicate with red ink location of fracture and give dimensions to some fixed point. Send Report to Assistant Superintendent Motive Power and Machinery Chicago, Ill.

CHICAGO & NORTHWESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

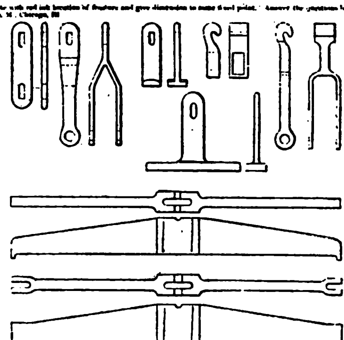
EQUALIZER. EQUALIZER STAND. SPRING HANGERS

Engine No.________ Date found on inspection______________190

or

Class________ Date of failure______________190 Reported at____________

NOTE.—Indicate with red ink location of fracture and give dimension to some fixed point. Answer the questions below and send report to Asst. Supt. M. P. & M., Chicago, Ill.



EQUALIZER.

Dimension and, if possible, sketch of section at point of fracture

Kind of metal.

Was there flaw at point of fracture

Probable cause of failure

EQUALIZER STAND.

Dimension and, if possible, sketch of section at point of fracture.

Kind of metal

Was there flaw at point of fracture?

Probable cause of failure.

SPRING HANGER

Dimension and, if possible, sketch of section at point of fracture

Kind of metal

Was there flaw at point of fracture?

Probable cause of failure

CHICAGO & NORTHWESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

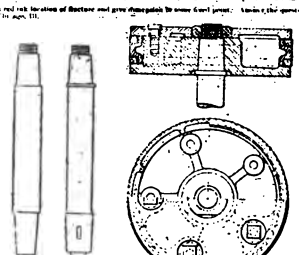
PISTON AND PISTON RODS.

Engine No.________ Date found on inspection______________190

or

Class________ Date of failure______________190 Reported at____________

NOTE.—Indicate with red ink location of fracture and give dimension to some fixed point. Answer the questions below and send report to Asst. Supt. M. P. & M., Chicago, Ill.



PISTON

Pattern No. { Bull ring. Spider.

Dimensions and, if possible, sketch at point of fracture

Kind of metal.

Kind of packing

Front packing ring

Back packing ring.

Was there blow hole or flaw at point of fracture?

Probable cause of failure

PISTON FOLLOWER

Pattern No.

Dimensions and if possible sketch at point of fracture

Kind of metal.

Was there blow hole or flaw at point of fracture?

Probable cause of failure.

PISTON ROD

Enlarged ends

Dimensions and, if possible sketch at point of fracture

Kind of metal

Was there flaw at point of fracture?

Did it show any old crack

Shop letter and date put on

Probable cause of failure.

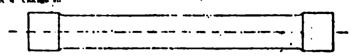
CHICAGO & NORTHWESTERN RAILWAY CO.

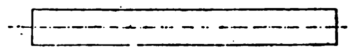
REPORT OF BREAKAGES OF LOCOMOTIVE PARTS

AXLE

Engine Number________ Date of failure ________________ Reported at ________________

NOTE.—Indicate with red ink location of fracture and give dimensions to some fixed point. Answer the questions below. Send report to Ass't Supt. M. P. & M., Chicago Ill.





Was it driving or truck axle?

Dimensions and, if possible, sketch of section at point of fracture

Kind of metal?

Was it front, middle or back axle?

Was the metal homogeneous?

Did it show crystallization?

Was there flaw at point of fracture?

Probable cause of failure?

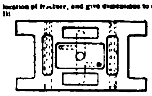
CHICAGO & NORTHWESTERN RAILWAY CO.

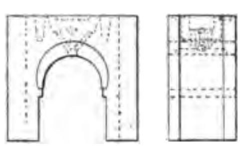
REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

DRIVING BOX AND BRASS.

Engine Number ________ Date of failure ________________ Reported at ________________

NOTE.—Indicate with red ink location of fracture, and give dimensions to some fixed point. Answer questions in below. Send report to Ass't Supt. M. P. & M., Chicago Ill.





BOX

BRASS

Pattern No.

Dimension and, if possible, sketch of section at point of fracture

Was it front, back or middle

Kind of metal

Was there flaw at point of fracture?

Probable cause of failure

Pattern No.

Dimension and if possible sketch of section at point of fracture

Was it front, back or middle

Kind of metal.

Was there flaw at point of fracture?

Probable cause of failure.

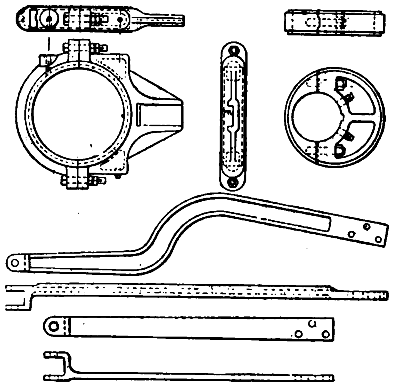
CHICAGO & NORTH WESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS

ECCENTRIC, ECCENTRIC STRAP, ECCENTRIC ROD

Engine No. ________ Date found on inspection ________ 190..
or
Class ________ Date of failure ________ 190.. Reported at ________

NOTE.—Indicate with red ink location of fracture and give dimension to some fixed point. Answer the questions below. Send report to Asst. Supt. M. P. & M., Chicago, Ill.



ECCENTRIC

Pattern No.
Forward ____ Back ____
Dimension, and if possible, sketch of section at point of fracture.

Kind of metal.
Was there flaw at point of fracture?
Probable cause of failure.

ECCENTRIC STRAP

Pattern No.
Forward ____ Back ____
Dimension, and if possible, sketch of section at point of fracture.

Kind of metal.
Was there flaw at point of fracture?
Probable cause of failure.

ECCENTRIC ROD

Dimensions, and if possible sketch of section at point of fracture.

Kind of metal.
Was there flaw at point of fracture?
Probable cause of failure.

____
Master Mechanic

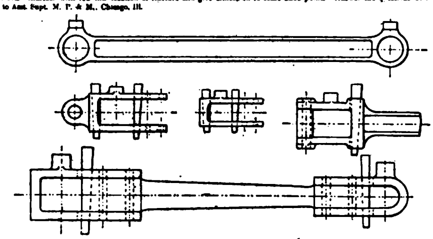
CHICAGO & NORTH WESTERN RAILWAY CO.

REPORT OF BREAKAGES OF LOCOMOTIVE PARTS.

SIDE ROD, MAIN ROD AND ROD STRAP.

Engine No. ________ Date found on inspection ________ 190__
or
Class ________ Date of failure ________ 190__ Reported at ________

NOTE.—Indicate with red ink location of fracture and give dimension to some fixed point. Answer the questions below. Send report to Asst. Supt. M. P. & M., Chicago, Ill.



SIDE ROD.

Front end,
Back end,
Dimensions and, if possible, sketch of section at point of fracture

Kind of Metal.
Was there flaw at point of fracture?
Probable cause of failure.

MAIN ROD.

Dimensions and, if possible, sketch of section at point of fracture.

Kind of Metal.
Was there flaw at point of fracture?
Probable cause of failure.

ROD STRAP.

Front strap,
Back strap,
Dimensions and, if possible, sketch of section at point of fracture.

Kind of Metal.
Was there flaw at point of fracture?
Probable cause of failure.

CHICAGO & NORTH-WESTERN RAILWAY COMPANY.

..................*Div.* **MOTIVE POWER AND MACHINERY DEPT.** ....*190*......

To..................................*M. M.*

Engine No...............*Train No.*..............*Date*..............*Departed from*..................

at..............*M. Arrived at*..................................*at*..............*M.*

Enginemen will fill out one of these forms for each trip, giving each delay of **THREE** minutes or more from whatever cause, and state the cause of each delay.

PLACE DELAYED	TIME DELAYED	STATE CAUSE OF DELAY AFTER EACH POINT	MADE UP TO STATION	TIME IN MINUTES
Delayed leaving				
Late arriving				

Signed,

....***Engineman.***

CHICAGO & NORTH-WESTERN RAILWAY CO.

OFFICE OF SUPERINTENDENT OF MOTIVE POWER AND MACHINERY.

The President: This paper is now open for discussion.

Mr. T. E. Adams (St. L. & S. W. Ry.): On page four of the paper, in the fourth paragraph, " If the failure is due to long hours on the road the information is of value to the Superintendent, who can determine the necessary action for increasing the speed of the train or trains. From the same records his attention is forcibly brought to the results of inferior coal, poorly designed and operated coaling stations, scanty and bad-water supplies, overloading of engines, indifferent train dispatching, lack of harmony in action on the part of the men in charge of the trains."

During the discussion yesterday, Mr. Pratt asked the question: " What is to be done with our firemen? "

I certainly believe that this is a very important question, and should be given careful consideration along the line of intelligent and economical use of fuel. Professor Hibbard called our attention yesterday to the schools of the United States as compared with those of Germany. I wish to say that, at the present time, there is not in Germany, France or the United States, including the Purdue and Cornell Universities, any course of instruction being taught on the economical and intelligent use of fuel. The time has come when the engineers and firemen on railroads, as well as the stationary plants of this country, should be educated in the use of fuel.

It was further stated in the discussion that the question of Special Apprentices was a most important one. I am sorry to say that I was unfortunate enough not to have had the advantage of a technical education, but I consider what was said with regard to special apprentices along the right line. One may come from a university or a country school, but if he does not know that the first letter of the alphabet is A, then his education does not do him any great amount of good. The technical student in the mechanical line should be educated in the use of fuel, and if this particular part of the business was understood, he would not only be a credit to himself, but to the university from which he graduated, and his knowledge would be one of economy to the railroads and individual plants.

We meet in this convention from time to time for what

purpose? For the purpose of discussing methods to produce economy, and to study what is of interest in the operation of railroads, and to avoid failures. I believe this paper is one of the most important papers presented before this convention. There is no one in the railroad business, be he either in the operating or the mechanical department, but knows that on any railroad one of the greatest drawbacks in the operation of the road is failures.

For a number of years I was a locomotive engineer, and if I had a good fireman I was a successful engineer, but if I had a fireman who was not able to fire an engine properly, I was not a successful engineer, owing to the fact that I did not at that time know how to instruct him in the use of fuel. I went over the matter carefully and came to the conclusion that if I was to be a first-class engineer, I should certainly be able to instruct my fireman in the use of fuel when he did not know how to use it properly. I made up my mind that there was something in connection with this question that I did not understand and that I would make a study of it for the purpose of instructing my fireman when necessity required. During the last ten years that I ran a locomotive I gave close attention to the intelligent and economical firing of a locomotive, and I am still giving the matter close supervision notwithstanding that for the last few years I have been in other service.

We believe to-day that the fuel question is one of the most important things to be understood in the handling of engines or stationary plants. What is there to be learned? First, that when slack coal is put on the tender of an engine it is not necessarily an inferior grade of coal; second, that the firemen must be taught to fire that grade of coal and to avoid fire clinkering, flues honeycombing, and netting in the front end stopping up, etc. In numerous cases where fires are clinkered and trains reduced on account of engines not steaming, it is not the failure of the engine or fuel, but due to the operation of same. One of the most important things that we have learned in connection with this matter is this, and it is being done to-day; that engineers and firemen can be taught to avoid any kind of fuel clinkering. It is possible and I believe I am honest when I say that

the majority of the coal used for fuel purposes as a general thing to-day will not clinker if it is properly used. As an illustration: In a street railway power plant in one of the largest cities it was necessary to call the fire department to put out a fire in the clinkers, or coal that had not been consumed, that had been shoveled from the cinder pit. In another plant of the same street railway, using chain grates and the same grade of coal but very fine, or slack, there was scarcely a clinker and very little coal that had not been consumed.

I do not desire to take up further time, but will say that in my judgment it will be of great interest to this convention to go into this matter thoroughly, notwithstanding superheaters, or other methods for the economical use of fuel, and, further, I believe that the educating of engineers and firemen, and all concerned, in the use of fuel, will bring about grand results in the practical operation of railroads in this country.

Where the method has been put into practice, great interest has been shown by engineers and firemen in trying to study out the practical idea; and the most important feature in making satisfactory progress in this direction is not only instructing along practical lines, but of being able to get the engineers and firemen interested in the subject with us.

MR. F. F. GAINES (C. of Ga. Ry.): This is a very valuable report in many respects, but I think one of the most valuable features of the whole report is in the last sentence, where reference is made, "that it is hoped that some standard agreement can be reached for recording and classifying engine failures." Probably all of us who have had to do with engine failures have had more or less trouble in determining with the proper department whether it was an engine failure, a man failure, or some other kind of failure, and as this question involves not only the motive power department in getting down to a standard of what an engine failure consists of, it seems to me this is a question this Association could well afford to assign to a committee to confer with the American Railway Association, to determine what would be a correct standard for engine failures and get down to a basis that would help us to decrease the number of these failures.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): There are

many good things and many good suggestions in the paper, but referring to the first blank, I do not think it provides for quick enough action. I like a form of blank which reads: "An engine failure from any cause must be reported to the train dispatcher by the engineer at the first point where the train makes a stop." This report must then be transmitted to the roundhouse foreman, and if there has been an engine delay or failure, state so in this way: "Engine No. ——, Due to arrive at ——, had an engine failure account of ————." This puts the roundhouse foreman in advance in touch with what he may expect to have to meet when that engine arrives. After the engine arrives and the proper inspection has been made to determine what is the cause of the failure, and what action will have to be taken to remedy it, it then devolves upon the roundhouse foreman to advise the train dispatcher that engine No. —— will be repaired and ready for service at such a time.

The second blank I do not like because it admits of too slow action. I like a blank in which the train dispatcher, the Superintendent, the Master Mechanic, or the Master Car Builder of the district, reports at the end of each twenty-four hours, showing that there have been certain engine failures, from such a cause, or car failures from such a cause occurring on the division during the last twenty-four hours. That is the method we pursue. Once each week the Master Mechanic or the Master Car Builder makes a résumé of all the delays that have occurred in his district, and furnishes them to the General Master Mechanic or the Superintendent of Motive Power, somewhat on the lines as laid down on the blank, as shown. I see nothing to criticise in this report; in fact, I consider it an excellent idea to try to standardize these various locomotive failures, but I do say there are better types of blanks in use than the first two indicated in the paper.

MR. E. A. MILLER: Regarding engine failures [illegible] that about two years ago we adopted a blank by [illegible] neer reports directly to the Superintendent of Mo[illegible] at the end of his trip any failure [illegible] of that failure. From these blanks [illegible] monthly, showing cause of failure [illegible] different enginehouses [illegible]

our engine failures. We found in many cases we were able to take up the cause of failure with the Master Mechanic quickly and remedy the evils before they became epidemic.

MR. THOMAS ROOPE (C. B. & Q. R. R.): The committee has presented to us what it thinks is the best method to adopt to avoid engine failure and also to report engine failures. In my opinion, if we would aim to get something to avoid these failures and talk along those lines, we would not need so many blanks. We find that the successful performance of a locomotive is in the hands of many. The first thing necessary is proper construction. After that is done the work of proper operation should be attended to, and this operation should be well checked, and we should not overlook the fact that a great amount of the success of the locomotive is in the hands of the enginemen. By getting their coöperation we accomplish considerable. We find that our best returns are by inspection and putting the work in individual hands, doing everything we can to prevent engine failures, and not waiting until they occur. Injectors, air pumps, etc., do not fail in the roundhouse; it is always on the road. On that account we should take care of these parts at certain intervals and know that the work is well done.

MR. GARSTANG: I move that the discussion be closed.

(Carried.)

PRESIDENT DEEMS: We will now have the report of the Committee on Subjects.

The Secretary presented the following report of the Committee on Subjects:

REPORT OF COMMITTEE ON SUBJECTS.

To the Members of the
American Railway Master Mechanics' Association:

Your committee, appointed to suggest subjects for the noon-hour discussion at the 1907 convention, also subjects for committee work and individual papers for the 1908 convention, would report as follows:

TOPICAL DISCUSSION.

First day:

Apprenticeship System on the New York Central Lines.
To be opened by Mr. C. W. Cross.

Second day:

1. Is it desirable to eliminate water gauge glasses on locomotives to enforce the use of gauge cocks?

To be opened by Mr. F. F. Gaines.

2. Relative merit of outside and inside delivery pipes in connection with locomotive injectors.

To be opened by Mr. Strickland L. Kneass.

Third day:

1. The corrugated tube for locomotive service with the view of bringing out the reasons and advantages for its use.

To be opened by Mr. G. W. West.

2. What is the best metal for hub liners for driving and engine truck wheels, the best method of applying and the limiting lateral hub play for such wheels before repairs are required?

To be opened by Mr. J. F. Dunn.

COMMITTEE REPORTS.

1. Laboratory test of various valve gears being used — Stephenson, Walschaert, Alfree-Hubbell, and Young — at Purdue or Altoona, to determine their relative efficiency.

R. D. Smith (Chairman), F. H. Clark, W. F. M. Goss.

2. Best system of washing out and refilling locomotive boilers, including blow-off lines, flushing tanks, hot wells, and other similar methods and data pertaining to benefits in the way of reducing defects in fire-box sheets, staybolts and tubes.

H. T. Bentley (Chairman), L. H. Turner, W. R. McKeen.

3. Organization of large railroad shop forces.

H. H. Vaughan (Chairman), James Milliken, W. H. Lewis, T. S. Lloyd, A. E. Manchester.

4. A system of accounting for labor and material for railway repair shops.

H. Emerson (Chairman), T. H. Curtis, Le Grand Parish.

5. Handling scrap.

H. D. Taylor (Chairman), D. J. Redding, A. Forsyth.

6. The use of castellated nuts for machinery of locomotives with a view of having some standard dimensions established.

Committee to be appointed by the Executive Committee.

INDIVIDUAL PAPERS.

Is it desirable to have uniform specifications and drawings of locomotives covering the most common types and sizes?

To be presented by Mr. G. M. Basford.

Standard definition of the term "engine failure," with a list of locomotive characteristics and the numerous varied conditions of operation on which any definition would need to be predicated, in order to enable comparison to be made.

To be presented by Mr. M. K. Barnum.

Design and strength of crank axles for balanced compound locomotives.

To be presented by Mr. F. J. Cole.

HENRY BARTLETT (Chairman),
J. A. CARNEY,
R. P. C. SANDERSON,
Committee.

BOSTON, MASS., April 8, 1907.

THE SECRETARY: I move that the report of the Committee on Subjects be received and the suggestions referred to the Executive Committee to consider when it formulates its program for next year.

(Carried.)

PRESIDENT DEEMS: We will now have the report of the Committee on Resolutions:

The Secretary read the following report:

WHEREAS, This convention has been more than usually successful in attendance, the character of reports and discussions, and in the large number of important and interesting exhibits, therefore, be it

Resolved, That the hearty thanks of the Association be extended to the President for his able and inspiring address; to the officers of the Association, especially to the Secretary, for his conscientious and efficient service; to the technical committee and the authors of papers for their painstaking presentation of subjects for discussion; to the Committee of Arrangements for providing so well for the convention; to the Pennsylvania Railroad and Central Railroad of New Jersey, and the Philadelphia & Reading for special trains placed at the disposal of the members, and to the Baldwin Locomotive Works for their kind invitation to visit their plant; to the hotels for their hospitality and comforts provided; to the railroads for courtesies extended; to the Supply Men's Association, and especially to Mr. B. V. Crandall, the secretary, to the technical press, and especially to the *Daily Railway Age,* for interest in and aid to the Association.

MR. J. F. WALSH: I move that the report be received.

PRESIDENT DEEMS: We have a topical discussion which was carried over from yesterday, which will be opened by Mr. Strick-

land L. Kneass. It is on the following subject: Relative merits of outside and inside delivery pipes in connection with locomotive injectors.

RELATIVE MERITS OF OUTSIDE AND INSIDE DELIVERY PIPES IN CONNECTION WITH LOCOMOTIVE INJECTORS.

By MR. STRICKLAND L. KNEASS.

Consideration of the relative merits of outside and inside delivery pipes must include the design of the boiler, the safety of passengers, and the convenience to the enginemen, as well as flue mileage and the relative efficiency of the two methods of feeding.

The main check has been applied to the back head of English and Continental engines for many years, and this may be regarded as the standard location in the British Isles. It is true that the construction of the English locomotive boiler and cab yields readily to this arrangement, but there may be other reasons at the bottom. The chief objection against projecting side checks is that of danger to passengers, as serious accidents have occurred from the shearing of the boiler check by the upsetting of the locomotive or the derailment of a passing train. The question of safety has been partially met by an internal side check, but it is doubtful if this form is entirely satisfactory, as it is difficult to keep steamtight, and impossible to examine or regrind without relieving the boiler pressure. The extreme length of the branch pipe on large locomotives is also disadvantageous, on account of the cost of bending, the present high price of copper, and because of the weakening of the section at the bends.

It is very difficult to bend pipe and maintain a circular section. The cross section is almost always elliptical or the material strained. The result is creeping of the pipe and occasional bursting when subject to excessive back pressure. I have taken indicator diagrams of the pressure in the branch pipe while starting and stopping an injector, rotating the drum by the stroke of the starting lever. An analysis of the diagram is of interest; with careful handling, the pressure rises gradually from zero to boiler pressure; quick careless starting of the feed causes an overpressure double that carried on the boiler, which may weaken or burst the branch pipe. Creeping due to flattened bends causes

undue strain on the boiler check and the pipe joints. The writer has noticed one instance where a main check was unscrewed one-eighth turn by the warping of the branch pipe; in this specific case, the difficulty was corrected by using a check with a side instead of a bottom inlet.

The location of the boiler check upon the back head, with internal feed-pipe delivery at the forward end, gives short direct and protected valves and pipe connections. It usually offers a convenient location for the two injectors, placing the operating levers directly beside the engineer and fireman, and out of the way of the reverse lever and throttle. The engineer then has his air brake and feed valves directly beside him; this enables him to feed the boiler to the best advantage with the least possible trouble to himself, all of which make for the life of tubes and the advantage of the railroad. Where locomotive appurtenances are arranged so as to be convenient to the engineer, a conscientious employee will operate them economically; but if an engineer has to rise from his seat and reach a considerable height to apply or adjust his injector, it stands to reason that the feed will be intermittent, and simply used to fill up the boiler as necessity requires, without the careful adjustment of the quantity required for continuous feed or to maintain a constant water level. Further, as the sprinkler valve is connected to the feed on the left-hand back-head injector, both can be operated by the fireman while on the deck of the cab.

In regard to the location of the back-head check, it may be said that the outlet should enter the boiler below the low water level. The delivering pipe, connecting the back-head valve with the front end of the boiler, should be not more than 2 inches above the crown sheet, so that steam may not enter through opened joints. This recommendation is made, as excessive pressure has been noted in three instances in the back-head valves, due to water hammer. This phenomenon, due to faulty connections, seems to be explainable as follows:

If the rear end of the delivering tube has an open joint within the steam space, steam is drawn in by the feed water flowing downward toward the immersed end of the delivering pipe when the injector is shut off. This steam is instantly condensed, form-

ing a partial vacuum, which causes a backward rush of water up into the delivering pipe against the back-head check. This causes a powerful water hammer; the remedy is simple:

The delivering pipe should be immersed as recommended above, the conduit may be made in the shape of a trough, or the joints kept tight. When correctly attached, no water hammer has been noticed. As joints are liable to work loose, it is considered safer to use one of the first two methods given.

In regard to the relative merits of the side or back-head feed, it is my opinion that the back-head system is preferable, as it gives an opportunity for even distribution of the feed water over a larger tube area instead of coming in direct contact with the nearer tubes and side sheets only. When the feed enters the side of the boiler, its greater density causes it to flow downward along the side sheet to the bottom of the boiler and the water leg, where it lies dead owing to sluggish circulation. This is aggravated by intermittent feeding, as frequent changes of temperature cause an expansion and contraction of the sheets and tubes which loosen the joints and produce leaks, increasing the cost of the flue mileage. On certain railroads there is applied to the shank of the side check an upward nozzle of reduced area, which forces the water above the tubes and into the steam space. This opening, however, is liable to be closed by incrustation when the water contains lime-bearing salts, and adds to the back pressure against which the injector must operate, reducing the life of the tubes.

In conclusion, it may be said that the safety of passengers and employees is the paramount consideration. Accidents from the use of the side check are many and of record. No such charge can be brought against the back-head method of feeding; while it is believed that the opportunity given for more perfect distribution of the entering feed water, and more careful adjustment of amount of water delivered, are arguments in its favor.

THE PRESIDENT: The subject is now opened for discussion. If no one wishes to discuss it we will pass to the next topic, "The corrugated tube for locomotive service, with the object of bringing out the advantages of its use," to be opened by Mr. Geo. W. West.

MR. G. W. WEST (N. Y. O. & W. Ry.): Secretary Taylor

advised me under date of April 30 that he would expect me to open the subject on "Corrugated tubes for locomotive service, with a view of bringing out the reasons and advantages for its use."

My attention was called first to the spirally corrugated tube in 1897, by Mr. Charles Whitney, who was at that time United States representative for a foreign-made corrugated tube. Previous to that time I had been experimenting with plain tubes to improve circulation and overcome the leaky tube habit and had fitted up three different classes of boilers that were originally designed for plain 2-inch and 2¼-inch tubes. It had always seemed strange to me that locomotive tubes, no matter how well they were set in the fire box or how poorly set in the smoke box, yet would invariably leak at the fire-box end, and when it was not considered bad practice to remove part of the set of tubes we often found two or three rows at the extreme sides and top would often outlast two settings of tubes near the center.

I concluded that there was one of two, possibly both, reasons for this other than the excuse often given — that of expansion and contraction; my reason was that the tube sheet in the fire box did not get the protection that the smoke-box sheet did or the tubes would leak where the poorest work was done, and the secret of smoke-box end of all tubes and the extreme top and side rows in the fire-box end not leaking was due to their having sufficient amount of water to fully protect them.

By welding 1¾-inch safe ends six or eight inches long on our 2-inch tubes and 2-inch safe ends on our 2¼-inch tubes, we could increase our tube-hole unions or bridges ¼ of an inch, thus strengthening the tube sheet and increasing the volume of water around the tube sheet where it was needed and also improving the circulation. This practice we have kept up and our engines steam better, tubes leak less and our trouble from clogging with cinders almost entirely done away with. So much for the plain tube.

When Mr. Whitney came to us with his corrugated tube, it was the same size throughout and I told him that if he would furnish us with a set with plain ends and the one end reduced in size to fit a flue sheet we were then putting in a passenger engine,

our No. 67, we would give him an order, which he did. We looked for trouble of clogging which never came. We were using at that time a very poor grade of bituminous coal and kept a gang of men at each terminal boring out tubes. I have forgotten how long this engine ran before a flue auger or any other device was used to clean them, but of sufficient time to make friends of the engineer, fireman and flue cleaners.

The corrugated tube made double the mileage of any plain tube we had ever before used in this particular engine or any of this class, and since the tubes have been made in this country we have applied them to all classes of engines, the wide and narrow ire box, burning both bituminous and anthracite coal, often a nixture of both, and we believe the extra first cost is soon met by ncreased mileage and saving of labor.

Another very important advantage in their favor is the almost otal elimination of hot sparks thrown from the stack. We have new passenger locomotive fitted with these tubes that is pulling ight cars up a continuous grade of twenty-one miles, eighty feet the mile and on the darkest night or through all our tunnels, wo of which are nearly a mile long, you can hardly see a red-hot park thrown from the stack. The effect of this is shown in the emperature of smoke-box front. The paint on the front end of ngines equipped with these tubes will outlast any three paintings n engines equipped with the plain tubes.

I have a statement from the New Jersey Tube Company which orroborates that, giving me a list of about twenty railroads which use these tubes, and I think it would be a subject well worthy of consideration. Unfortunately, I was disqualified from doing very much business after this statement was sent to me by the Secretary, and am unable to give you any data from other roads except one, which I am not at liberty to mention, but I thought it would be a subject well worthy of consideration.

The President: As this subject is so closely allied to some of the other subjects before us yesterday and to-day, it ought to be worthy of a good deal of careful consideration.

Mr. F. P. Roesch (Southern Ry.): We have one experimental set of spiral corrugated tubes in use on the Southern Railway Company which we applied last December and up to this

time we had had no trouble from flue leakage on account of the short length of time they have been in service. We have found practically no difference in the tubes clogging up over the plain tube. We use a very fine grade of coal and have more or less trouble with it clogging flues, but I can not see, with the corrugated tube, that it stops up any more or any less than with the plain tube. So far as the elimination of sparks is concerned, I am not in position to give any data on that because we use a spark arresting front end, the same as any one else, and we do not expect to get rid of the sparks with the corrugated tube or any other kind of tube, but it appears to me that if this tube will eliminate sparks that might escape, in practice we might do away with quite a number of devices we have in the front end now for the prevention of sparks, and in that way be able to obtain a little better or a little freer exhaust, that is, a freer and more unobstructed passage for the gases. As I understand the theory of this corrugated tube it is that the velocity of the gases is obstructed to a certain extent in their passage through the tube, and in that way more of the heat of the gases is absorbed by the water. However, as I said before, I am not in a position to give any definite information. I believe from what we have seen so far that there is something in its favor as regards flue leakage from the fact that another locomotive of exactly the same type that received plain tubes at the same time is now beginning to show signs of flue leakage, and it is only a question of a short time when the flues will have to be renewed. Whether this is altogether due to the spiral corrugated tube or the way in which both locomotives were handled, both in the same condition, and in the same class of service and operating under same conditions, I am not prepared to say. There might be something in favor of the corrugated tube due to its stiffening qualities; that is, it would not have the same tendency to vibrate that an ordinary tube has.

THE PRESIDENT: If there is any one else present who has had actual experience with these tubes he might give the Association the benefit of such experiences. If there is no further discussion we will consider the subject closed and pass on to the next topical subject, which is, "What is the best metal for hub liners for driving and engine truck wheels, the best method of

applying and the limiting lateral hub play for such wheels before repairs are required?" to be opened by Mr. J. F. Dunn.

THE SECRETARY: Mr. Dunn was not able to be present at the meeting, but he has sent a letter, which is as follows:

METHOD OF APPLYING HUB LINERS.

MR. J. F. DUNN (Oregon Short Line R. R.): I will not be able to attend the conventions this year, although I would like very much to do so.

In this connection would say that our experience has been that babbitt metal is the best material to take up "hub wear" and which we invariably apply to the face of the boxes by recessing same, dovetailing the outer edge of recess and drilling a few ⅞-inch holes into the face of the box; this to dowel the babbitt and prevent it sliding or turning. We also tin the face of the boxes, heating them sufficiently to melt the tinning while pouring the babbitt.

While the babbitt is not quite as durable as brass or bronze liners on the hubs of wheels it is much more economical and serves the same purpose, also prevents any cutting or undue wearing on either the hubs of the wheels or the face of the boxes.

We do not allow to exceed ⅝-inch lateral wear in driving boxes or ¾-inch in engine truck boxes.

THE PRESIDENT: This subject is now open for discussion. If there is any one present who has had experience with the method of applying hub liners I am sure that our members will be interested in hearing what they have to say, and we would like to have the benefit of their views.

MR. WILLIAM MCINTOSH (C. R. R. of N. J.): On our line we have used babbitt facing for driving boxes for some years and find it very efficient. In fact, it is superior to any bronze that we ever used for that purpose, especially against steel.

MR. E. W. PRATT (C. & N.-W. Ry.): It occurs to me that the metal that gives the best satisfaction will be somewhat dependent on lubrication, and inasmuch as so large a number of railroads are using grease for driving-box cellars I would like

to ask if any one has had experience in that direction. We have had quite a little trouble with the friction in the use of grease.

MR. J. F. WALSH (C. & O. Ry.): On account of the low temperature at which babbitt will melt we abandoned it four or five years ago and used bronze entirely for our hub liners, and I am now of the opinion that it is practically impossible to make a success of it with grease.

MR. F. P. ROESCH (Southern Ry.): We have had very poor success also with the use of babbitt on hub liners where we used grease cellars, so on my territory I have gone into bronze or brass, pouring it directly on the wheel centers, or the face of the driving box, as the case may require.

THE PRESIDENT: Is there any further discussion on this subject?

MR. G. W. WEST (N. Y. O. & W. Ry.): I would ask Mr. Minshull to state experiences on our road.

MR. P. H. MINSHULL (N. Y. O. & W. Ry.): We are using steel driving boxes and boiler steel hub plates on our driving wheels. For new work we babbitt the side of box as shown on page 314 of the Master Mechanics' Proceedings for 1901. On boxes that are worn so that we have to take up the side play, we tin the face of the box and babbitt the whole surface. We get very good results. We use both oil and waste and grease cellars on our engines and have very little trouble from hot boxes.

THE PRESIDENT: Do you make a complete facing of babbitt?

MR. WEST: We do in some cases, yes.

THOMAS ROOPE (C. B. & Q.): It is my opinion that Mr. Dunn's position is well taken. Mr. Dunn is in a section of the country with which all the gentlemen here are not familiar, and It was my experience that babbitt is much the preferable metal in a sandy country. Brass, I think, is much more expensive; it wears rapidly, and in the case of those who have set aside the babbitt, in many instances I believe it has been set aside because of poor quality and not being properly handled. Babbitt should be in every case sweated on the box. It will not do good work if applied in any other manner.

The President: I think Mr. Hill, of the Lake Erie & Western, can give us some experience on this subject.

Mr. J. Hill (L. E. & W. Ry.): We have had quite a little experience with the babbitt liners, and I have seen on other roads with which I have been connected where they had a great deal of trouble with the babbitt liners. In some cases the liner would be entirely gone before the engine would be anywhere near the point at which it should be shopped. In my experience I have found by pouring the brass liner in the wheel hub, bringing it out to the standard face and keeping up the lateral part, pouring the brass liner through the driving box, we had no trouble. We have been very successful with that, and I find we can run the engines from shopping to shopping without giving any further attention to the liners.

Mr. J. J. Thomas (A. L. C. R. R.): I have had a good deal of experience with soft metal liners. The road I am with now has been using them for over two years. When I first went there I found several metal liners were used in driving wheels. As a rule I found them a failure, for the reason that in many instances the liners would crack, and through not being sufficiently attached or fastened to the hub, they would fall off. I found that particularly the case with some Atlantic type engines we had, in sandy service, and, as a gentleman remarked just now, sometimes when the engines had been out of the shop only two months we had to shop them again for a hub liner. We changed our methods and put on brass liners on the hub, and they wore fairly well. About two years ago I tried the experiment of putting babbitt on the boxes instead of on the hub. In several instances where these liners were attached to the wheel hub and had worn out, I simply drilled the face of the box, cleaned the box and lined it with babbitt. I find it has given exceedingly good results. We are doing that now on practically all our engines and see no reason why we should change. I have tried it on all kinds of engines, large and small, and it has proven very satisfactory under our conditions.

Mr. D. J. Reading (P. & L. E.): There is one point I would call attention to, and that is where you use a babbitt head liner on the side of the driving box, you do not get the same amount of wear all over the hub. The babbitt does not wear away at the

same time that the end of the crown brass wears. I have seen hubs of wheels badly scored on that account. While the babbitt has been satisfactory for us on freight engines, we found on high-speed engines, our road having many curves, that we got the best results by using a plain hub on the wheel, cast steel or iron, and then putting a brass face on the box, recessing the wheel hub and putting in a loose cast-iron liner, which revolving at slower speed than the wheel reduces friction between the box and wheel hub, and getting practically the same metal on the face of the box as we would put on the hub of the wheel. I have seen good results by using a brass face on the box, recess the wheel box, and put in a cast-iron liner, which reduces the friction between the two ends.

MR. J. B. MICHAEL (Southern Ry.): I think it would be of great benefit if this Association could determine just exactly what would be the best metal for taking up the lateral play. I notice from this discussion we have different metals and several different metals are now being used. I also notice that it is a very hard matter to keep up the lateral play on our large engines; in fact it is very noticeable, and for that reason we should know, if it is possible, the very best practice. It is almost impossible to keep our large engines running any length of time without dropping a pair of wheels, and in some instances all of them, on this class of engines in order to take up the excessive lateral play.

M. D. FRANEY (L. S. & M. S. Ry.): I believe Mr. Hill was rather modest in explaining their method of pouring driving-box shells on the Lake Erie & Western. Some months ago I was delegated to investigate the method of pouring driving-box shells as introduced by Mr. Hill on the Lake Erie & Western. Five dovetails are slotted in the crown of the driving box for the purpose of holding the metal. The box is then placed on a suitable table and a cast-iron former or mandrel is fastened centrally in the box by means of wedges. After the mandrel is properly lined up and located it is removed from the box, and the box is heated on the interior by means of gasoline or fuel oil burners, the flame being directed against the inside crown of the box. This causes the free portion of the box to expand from 1/4 to 3/8 inches. After the box is heated the mandrel is dropped into its original posi-

tion, and the brasses poured between the box and the former. The practice appeared so satisfactory that we have adopted it on the Lake Shore & Michigan Southern Ry. It is our experience with this method of pouring brasses that when the box is cold the lower end of the box measures 1-16-inch less than it did before the box was heated. This is caused by the cooling of the brasses, and the tendency for the projections which fit closely into the dovetails to draw the box together.

Where we press the shell into the box we customarily find it would expand the box from 1-16 to 1/8 inch. Pouring the shell into the box has just the opposite effect. We have pressed several of the poured brasses out of the box, and find it required from 80 to 100 tons to remove them where the dovetails are properly shaped and the shell has perfect contact with the box.

We find with this method of pouring it is possible to pour the alloys at a lower temperature than when it is poured into sand moulds, and there is not the same tendency for the alloys to segregate. Broken samples of bearing metal poured in this manner show a much better fracture than those poured in the sand mould. It is our experience that the brasses do not work loose in the box as with the former method.

We are also pouring the hub liner on the box at the same time we pour the shell, making the hub liners and shells in one piece. Where we use steel driving boxes we also use a brass liner for shoe and wedge-bearing surface. We are now pouring these liners on the steel driving boxes and getting very good results.

We are also extending it to the pouring of liners in our eccentric straps and find where the bearing is poured in the metal mould we get a much better bearing metal than we would from the same mixture in the sand mould.

There is a marked saving in this practice over the method of pouring in a sand mould and machining the bearing.

Mr. W. E. Symons (Pioneer Cast Steel Truck Co.): In connection with the subject of a standard formula for a metal or a standard practice of applying the same for side liners on either engine truck or driving boxes on locomotives as referred to by one of the previous speakers, it has occurred to me that, possibly, any investigation made with these objects in view should be con-

ducted on lines with a view of determining the most suitable formula and method of application for service under the various conditions which might arise.

I assume the favorable experiences reported by letter from one member of the committee is that of Mr. Dunn, S. M. P. of the Oregon Short Line. If I am correct in this, then the experience reviewed is that on a mountainous road, equipped with heavy locomotives, operated on steep grades with sharp curvatures, while some of the members who are favorable to a different formula, or kind of metal, also a different method of application, are, doubtless, influenced in reaching a conclusion by their experience under entirely different conditions. One of the speakers reports excellent results with entirely different method and means of application; probably the lines with which he is connected are in a level country reasonably free from curvatures and equipped with light engines; therefore, it has occurred to me, that in following the matter up as an Association subject with a view of arriving at any standard, either as to the kind of metal, or the manner of application, that all of these conditions should be borne in mind, for what might be very satisfactory on one line might prove equally unsatisfactory on some other line.

Mr. F. P. Roesch (Southern Ry.): We have been told that the reason that the babbitt users are not successful with the use of babbitt as hub liners was because they did not know how to handle it. Now we are here for the purpose of being taught. I would like to know how to handle babbitt in order to use it successfully. It is a much cheaper metal, and if we can be taught to use it right, it is better for our purpose than bronze or brass.

Mr. Wm. McIntosh (C. R. R. of N. J.): I do not know that our method would meet the requirements of the locality of the gentleman who just spoke. We simply recess the boxes and face them with a good quality of babbitt, and we are using that facing for our fast passenger engines operating between New York and Philadelphia, New York and Atlantic City, and in the other direction between New York and Scranton, up the Lehigh Valley, around the curves and over the hills, in as strenuous service as it is possible to find anywhere. We also apply it to the heaviest

he has presided over our meetings at this session, and especially tain districts, and without any difficulty whatever.

Mr. F. P. Roesch (Southern Ry.): I would ask Mr. McIntosh whether he uses the grease cellar or depends on oil lubrication as a method of lubricating. That is where we find the trouble; it is in the lateral wear on drivers. I also desire to know about the thickness of the liners applied, as we find in applying soft metals to anything where it is subject to more or less shock, that the shock has a tendency to squeeze it out.

Mr. McIntosh: We are using grease in some cases, and oil in others, and we apply it in the ordinary manner. We apply about ¾ of an inch of babbitt and possibly a little heavier in some cases. The results of the babbitt facing on the box against the steel hub of the driving wheel are extraordinary with us. It seems that the babbitt does not wear much to speak of against the face of the hub of the driving wheel.

Mr. F. F. Gaines (C. of Ga. Ry.): Just one more remark concerning babbitt, which I would like to make. I found from experiment that if you pour babbitt and peen it with the ball of a hammer, going over the whole surface thoroughly from one end to the other, it will wear longer and give much less trouble from its getting loose. It makes it denser. It adds materially to the life of the babbitt, no matter where you use it.

Mr. G. W. Wildin (L. V. R. R.): On the Erie Railroad we abandoned brass hub liner and substituted cast iron with soft metal facing on the box. We made no difference whether the engine was using oil or grease as a lubricant in the cellar. We did not depend on the grease for lubricating between the hub and box, but used oil in all cases. Since I have been with the Lehigh Valley I find their practice is to use brass hub liners against steel boxes, and I notice considerable more trouble developing, but, of course, part of this may be due to the more crooked road. I am sure from my experience on the Jersey Central and on the Erie that if we should adopt the same practice on the Lehigh Valley we would get better results than at present.

Mr. E. W. Pratt: This individual paper has provoked so general a discussion, it seems to me it would be good to have in

concise form the experience of the various railroads, and I suggest that the Committee on Subjects consider that as a topic for a report at the next convention.

MR. F. M. WHYTE (N. Y. C.): The difficulty may come from the mixture — there is babbitt metal and babbitt metal; the mixture should be looked after.

MR. C. A. SELEY: The same thing is true of the brass.

THE PRESIDENT: The next business is the election of officers. The Secretary will read the provisions of the Constitution in regard to the election of officers.

The Secretary read the Constitution in regard to the election of officers, and said: The President has named as recording tellers Messrs. Garstang and West. They shall conduct the election and report results. The President has appointed as collecting tellers Messrs. Pratt and Cross.

THE PRESIDENT: The members will now prepare their ballots for President.

The ballots for President will now be collected and the members will prepare their ballots for First Vice-President.

MR. GARSTANG: I report the number of votes cast for President as 89. Necessary for a choice, 45. Mr. William McIntosh received 82; Mr. H. H. Vaughan, 4; Mr. Angus Sinclair, 1; John Howard, 1, and F. P. Roesch, 1. Mr. McIntosh having the necessary majority, is elected President.

MR. P. H. PECK: I move that the Secretary cast the ballot of the convention for the unanimous election of Mr. William McIntosh as President. (Carried.)

THE SECRETARY: I have pleasure in casting the ballot of the Association for Mr. William McIntosh as President for the ensuing year. [Applause.]

MR. MCINTOSH: Gentlemen, I am fully sensible of the honor and will do my best to justify your judgment. [Applause.]

THE PRESIDENT: The ballots for First Vice-President will now be collected, and the members will prepare their ballots for Second Vice-President.

MR. GARSTANG: I report the number of votes cast for First Vice-President as 96. Necessary for a choice, 49; Mr. H. H.

Vaughan received 86; Mr. John Howard, 7 (others scattering). Mr. Vaughan having the necessary majority is elected First Vice-President.

MR. WALSH: I move that the election of Mr. H. H. Vaughan as First Vice-President be made unanimous. (Motion carried.)

THE PRESIDENT: The ballots for Second Vice-President will now be collected and the members will prepare their ballots for Third Vice-President.

MR. GARSTANG: I report the number of votes cast for Second Vice-President as 95; necessary for a choice, 48. Mr. George W. Wildin received 81; Mr. John Howard, 8 (others scattering). Mr. Wildin having received the necessary majority, is elected Second Vice-President. [Applause.]

MR. P. H. PECK: I move that the Secretary cast the unanimous ballot of the Association for Mr. Wildin as Second Vice-President.

THE PRESIDENT: The ballots for Third Vice-President will now be collected, and the members will prepare their ballots for the Executive Committee.

MR. GARSTANG: I report the number of votes cast for Third Vice-President as 90; necessary for a choice, 46. Mr. F. H. Clark received 38; Mr. John Howard, 24; Mr. A. Stewart, 6; Mr. C. A. Seley, 3. (Others scattering.) There is no election.

THE PRESIDENT: It will be necessary to take another ballot for Third Vice-President.

MR. GARSTANG: The ballot for Third Vice-President having been again taken, we find that the total number of votes cast is 89; necessary for a choice, 45. Mr. F. H. Clark received 54; Mr. John Howard, 23; Mr. A. Stewart, 4; Mr. C. A. Seley, 3. (Others scattering.) Mr. Clark having received the necessary majority he is declared to be elected Third Vice-President.

MR. E. W. PRATT: I move that the Secretary be authorized to cast the unanimous ballot of the Association for Mr. Clark as the unanimous choice of the meeting. (Carried.)

MR. C. A. SELEY: I move that in casting the ballot for four members of the Executive Committee, that three of them shall be

elected for the two-year term, the three receiving the highest number of ballots, and the member receiving the next highest number of ballots shall be elected for the one-year term, to fill out the unexpired term of Mr. F. H. Clark as a member of the Executive Committee. (Carried.)

THE PRESIDENT: The tellers will report on the vote for the Executive Committee.

MR. GARSTANG: The four gentlemen receiving the highest number of votes are Mr. Seley, 42; Mr. Whyte, 39; Mr. Howard, 24; Mr. Mitchell, 24. We did not add up the total number of votes cast because there are about 52 candidates here running from 1 to 3 or 4 votes apiece. The names mentioned received the highest number of votes and are entitled to the place.

(The Secretary cast a ballot for the four gentlemen named, Messrs. Seley, Whyte, Howard and Mitchell.)

THE PRESIDENT: Messrs. Howard and Mitchell received the same number of votes, 24 each. One of those will serve for two years and the other for one. If there is no objection the Chair will rule that Mr. Howard serves for two years and Mr. Mitchell for one.

THE SECRETARY: Then, under the Constitution, Messrs. Seley, Whyte and Howard are elected for two years and Mr. Mitchell for one year, the unexpired term of Mr. Clark.

THE PRESIDENT: I want to express my very sincere thanks for the assistance that I have received at the hands of the members. I feel that they have been more kind to me than I deserved, because of the fact that with my many duties I have sometimes found it difficult to do what I wished in the way of looking after the work, and I am sure that, had it not been for the kindness of the members I would not have gotten through as nicely as I have. I feel very grateful indeed and I now take pleasure in turning the gavel over to Mr. McIntosh. [Applause.]

(President William McIntosh in the Chair.)

MR. G. W. WILDIN (L. V. R. R.): Mr. President and gentlemen, it is an unexpected pleasure on my part to be permitted to propose a vote of thanks of our Association to our retiring President, Mr. Deems, for the very able and efficient manner in which

he has presided over our meetings at this session, and especially do we owe him our thanks for the very splendid address which he delivered. That address should serve as a landmark for our guidance for some time to come, and as food for reflection.

May I now ask you to extend to Mr. Deems your thanks by a rising vote?

(The motion was carried by a rising vote.)

THE SECRETARY: Last fall, when the Executive Committee decided to come to Atlantic City, the Supplymen promised that we would have good weather. We have not had very good weather, and I see the Chairman of the Supplymen's Association is here. I rather think he has something on his mind. He may want to tell you something about the weather, and he may not; but Mr. Mark A. Ross, Chairman of the Supplymen's Association, is here. I would like, Mr. President, if the privileges of the floor could be extended to Mr. Ross for a few minutes.

PRESIDENT MCINTOSH: Mr. Ross, the privilege of the floor is extended and we would like to have you come forward.

MR. MARK A. ROSS: Mr. President and members of the Association, as the representative of the Railway Supply Manufacturers' Association, I wish to compliment you and the members of the Master Mechanics' Association on your successful convention, and to assure you of our appreciation of your untiring efforts to help us in making this exhibition the most successful in the history of our organization.

Mr. Deems, as a token of our appreciation and in pursuance of an honored custom I take great pleasure in presenting to you this Past President's Badge, and I trust that you will be permitted to wear it at many future conventions. [Applause.]

Mr. President, answering your worthy Secretary's remarks, I will say for your information that we have a written contract with the Hotel Men's Association to furnish us good weather, and after the convention is over the Executive Committee of the Railway Supply Manufacturers' Association will get all the redress that they possibly can from the Hotel Men's Association for giving us this kind of weather. [Applause and laughter.]

On motion of Mr. J. F. Walsh the convention then adjourned.

CIRCULAR RELATING TO LETTER BALLOT.

DEAR SIR,—At the convention of 1907 the following subjects were ordered submitted to letter ballot.

They are stated in paragraphs 1 to 11 below, and each member is requested to write "Yes" or "No" on the accompanying voting slip and mail it to the Secretary, 390 Old Colony building, Chicago, Illinois.

A vote "Yes" will mean that the subject is to be adopted as a standard, and a vote "No" will mean that it is not to be adopted.

The votes will be counted August 19, 1907, and any votes received at the Secretary's office after that date will be excluded.

All votes must be "Yes" or "No"; no qualified votes will be considered.

TIRE SHRINKAGE AND DESIGN OF WHEEL CENTERS.

As a result of the work of the committee during the last three years the following specifications are submitted for adoption as standard:

SHRINKAGE OF WHEEL CENTERS.

1. That a shrinkage of 1-80 inch per foot in diameter be allowed for cast iron and cast steel centers less than 66 inches in diameter.

2. That a shrinkage of 1-60 inch per foot in diameter be allowed for cast iron and cast steel centers 66 inches and over in diameter.

3. That 72 inches be included in the list of standard sizes of tires.

SPOKES.

4. In order to properly support the rim and resist the tire shrinkage, the spokes should be placed from 12 to 13 inches apart from center to center, measured on the outer circumference of the wheel center.

The following rule is recommended:

Number of spokes to equal the diameter of center divided by 4. If the remainder is one-half or over, use one additional spoke. The exact spacing of the spokes according to this rule would be 3.1416 x 4.1256.

There is a feeling among pattern makers and foundrymen that an uneven number of spokes should be used to avoid getting two spokes directly opposite each other in a straight line. The following table has been made up on this basis:

		—Recommended—	
Diameter.	Circumference.	Spokes.	Pitch.
38	119.38	11	10.8
44	138.23	11	12.5
48	150.8	11	13.6
50	157.	13	12.6
54	169.65	13	13.
56	176.	13	13.5
60	188.5	15	12.6
62	194.8	15	13.
66	207.3	15	13.8
68	213.6	17	12.5
70	220.	17	12.9
72	226.2	17	13.3
74	232.5	17	13.6
76	238.76	19	12.6
78	245.	19	12.9
82	257.6	21	12.2
86	270.2	21	12.9
90	282.2	23	12.2

5. Spokes at crank hub should not be located at center line of wheel, but on either side, so as not to bring a short spoke directly in line with crank pin hub. Section of spoke at large end to have an area of from 9 to 10 square inches, with form as shown in Fig. 1. Section of spoke at small end to have an area of from 5¾ to 6 inches, with form as shown in Fig. 2. These sections are taken at the base of the fillets uniting the spoke to the hub and rim.

RESULT OF LETTER BALLOT.

CHICAGO, ILL., August 20, 1907.

DEAR SIR,—The letter ballot which closed August 19, 1907, resulted as follows:

	SUBJECTS.	Affirmative.	Negative.	Total.	Votes Necessary.	Result.
1.	Wheel center shrinkage $\frac{1}{80}$-in. per ft.	108	22	130	87	Adopted.
2.	" " " $\frac{1}{60}$-in. "	113	17	130	87	"
3.	72 inches as a standard size for tires.	128	2	130	87	"
4.	Spacing of spokes................	124	3	127	85	"
5.	Location of spokes...............	122	3	125	83	"
6.	Cast-steel driving wheel centers ...	124	2	126	84	"
7.	Rims cast solid without cores.....	110	13	123	82	"
8.	Section of rim without retaining rings..........................	117	8	125	83	"
9.	Distance between hubs...........	121	6	127	85	"
10.	Retaining rings for passenger locomotive driving wheel tires.......	49	75	124	83	Rejected.
11.	Retaining rings for freight locomotive driving wheel tires.........	20	106	126	84	"

JOS. W. TAYLOR,

Secretary.

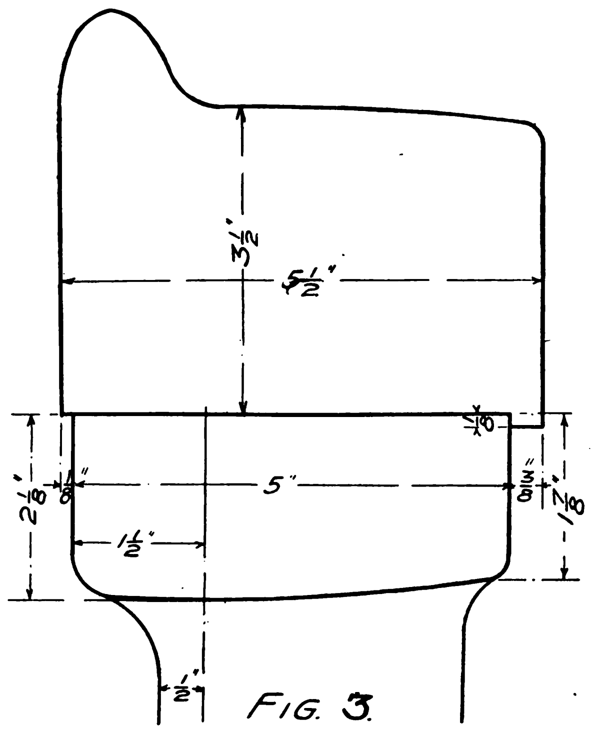


FIG. 3.

HUBS.

9. The standard distance between hubs shall be 55 inches. This permits the use of a practically straight spoke without dish on the inside.

RETAINING RINGS.

When the report of the committee on tire shrinkage was considered, a motion prevailed that the question of retaining rings be referred to letter ballot vote of the Association. In order to determine this in so far as it can be —

10. Do you recommend the use of retaining rings for passenger locomotive driving tires? If so, what design do you prefer?

11. Do you recommend the use of retaining rings for freight locomotive driving tires? If so, what design do you prefer?

The questions to be decided are: Do you favor the adoption as standard of the recommendations outlined in the preceding eleven paragraphs? File your answer "Yes" or "No" on enclosed voting slip and return same to the undersigned.

JOS. W. TAYLOR,
Secretary.

LETTER BALLOT VOTING SLIP.

1. Shrinkage, 1-80 inch per foot. ....
2. Shrinkage, 1-60 inch per foot. ....
3. 72 inches to be included in standard sizes. ....
4. Spacing of spokes. ....
5. Location of spokes. ....
6. Centers cut and uncut. ....
7. Rims cast solid with cores. ....
8. Section of rim without retaining rings. ....
9. Distance between hubs. ....
10. Retaining rings for passenger locomotive driving tires. ....
11. Retaining rings for freight locomotive driving tires. ....

(Name) ....

(Title and Company) ....

(Address) ....

RESULT OF LETTER BALLOT.

CHICAGO, ILL., August 20, 1907.

DEAR SIR,—The letter ballot which closed August 19, 1907, resulted as follows:

	SUBJECTS.	Affirm-ative.	Nega-tive.	Total.	Votes Necessary.	Result.
1.	Wheel center shrinkage $\frac{1}{80}$-in. per ft.	108	22	130	87	Adopted.
2.	" " " $\frac{1}{60}$-in. "	113	17	130	87	"
3.	72 inches as a standard size for tires.	128	2	130	87	"
4.	Spacing of spokes.	124	3	127	85	"
5.	Location of spokes.	122	3	125	83	"
6.	Cast-steel driving wheel centers . . .	124	2	126	84	"
7.	Rims cast solid without cores	110	13	123	82	"
8.	Section of rim without retaining rings	117	8	125	83	"
9.	Distance between hubs.	121	6	127	85	"
10.	Retaining rings for passenger locomotive driving wheel tires.	49	75	124	83	Rejected.
11.	Retaining rings for freight locomotive driving wheel tires	20	106	126	84	"

JOS. W. TAYLOR,

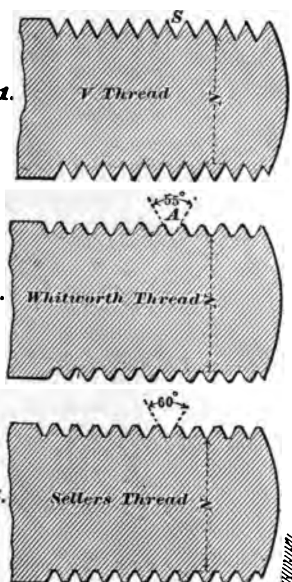
Secretary.

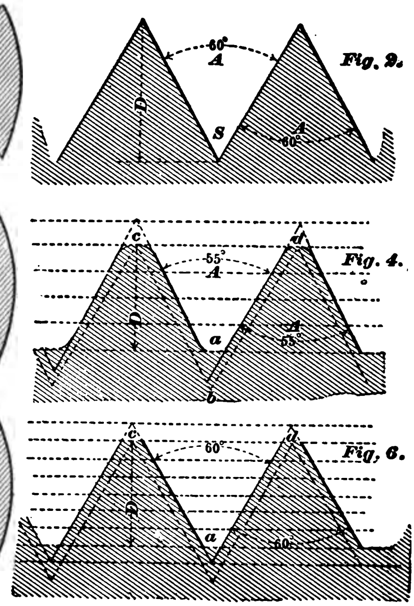
STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

SCREW THREADS, BOLT HEADS AND NUTS.

At the convention of 1870 the report of a committee recommending the United States Standard Screw Thread was adopted. The forms and dimensions of the threads are shown below:

Fig. 1.
Fig. 3.
Fig. 5.





SCREW THREADS. SELLERS' STANDARD.

Mr. Sellers, who proposed this system of screw threads, described it in an essay read before the Franklin Institute of Philadelphia, April 21, 1864, as follows:

"The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the accompanying diagram in which Figs. 1 and 2 — the latter on an exaggerated scale — represent a sharp thread, Figs. 3 and 4 a rounded top and bottom to the English proportion, and Figs. 5 and 6 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at sixty degrees, the same as the sharp thread, it being more readily obtained than fifty-five degrees; and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch; the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula:

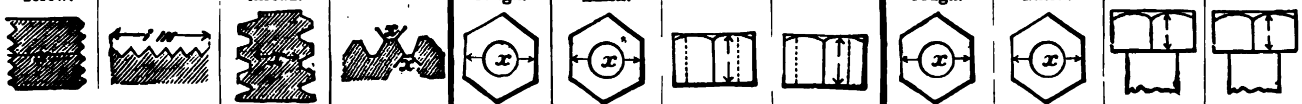
$$\textit{Diameter} - \frac{1{,}299}{\textit{number of threads per inch.}}$$

At the convention of 1892 the Association adopted as standard the United States standard sizes of nuts and bolt heads.

At the convention of 1903 the arrangement of these standards was made to conform to the arrangement as adopted by the Master Car Builders' Association.

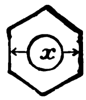
The accompanying tables are reprinted from Mr. Sellers' essay. They give the proportions of his standard screw threads, nuts and bolt heads.

PROPORTIONS FOR SELLERS' STANDARD SCREW-THREADS, NUTS AND BOLTS.

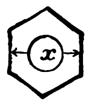


Screw-Threads.				Nuts.				Bolt Heads.			
Diameter of screw.	Threads per inch.	Diameter at root of thread.	Width of flat.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.
1/4	20	.185	.0062	1/2	7/16	1/4	3/16	1/2	7/16	1/4	3/16
5/16	18	.240	.0074	19/32	17/32	5/16	1/4	19/32	17/32	19/64	1/4
3/8	16	.294	.0078	11/16	5/8	3/8	5/16	11/16	5/8	11/32	5/16
7/16	14	.344	.0089	25/32	23/32	7/16	3/8	25/32	23/32	25/64	3/8
1/2	13	.400	.0096	7/8	13/16	1/2	7/16	7/8	13/16	7/16	7/16
9/16	12	.454	.0104	31/32	29/32	9/16	1/2	31/32	29/32	31/64	1/2
5/8	11	.507	.0113	1 1/16	1	5/8	9/16	1 1/16	1	17/32	9/16
3/4	10	.620	.0125	1 1/4	1 3/16	3/4	11/16	1 1/4	1 3/16	5/8	11/16
7/8	9	.731	.0138	1 7/16	1 3/8	7/8	13/16	1 7/16	1 3/8	23/32	13/16
1	8	.837	.0156	1 5/8	1 9/16	1	15/16	1 5/8	1 9/16	13/16	15/16
1 1/8	7	.940	.0178	1 13/16	1 3/4	1 1/8	1 1/16	1 13/16	1 3/4	29/32	1 1/16
1 1/4	7	1.065	.0178	2	1 15/16	1 1/4	1 3/16	2	1 15/16	1	1 3/16
1 3/8	6	1.160	.0208	2 3/16	2 1/8	1 3/8	1 5/16	2 3/16	2 1/8	1 3/32	1 5/16
1 1/2	6	1.284	.0208	2 3/8	2 5/16	1 1/2	1 7/16	2 3/8	2 5/16	1 3/16	1 7/16
1 5/8	5 1/2	1.389	.0227	2 9/16	2 1/2	1 5/8	1 9/16	2 9/16	2 1/2	1 9/32	1 9/16
1 3/4	5	1.491	.0250	2 3/4	2 11/16	1 3/4	1 11/16	2 3/4	2 11/16	1 3/8	1 11/16
1 7/8	5	1.616	.0250	2 15/16	2 7/8	1 7/8	1 13/16	2 15/16	2 7/8	1 15/32	1 13/16
2	4 1/2	1.712	.0277	3 1/8	3 1/16	2	1 15/16	3 1/8	3 1/16	1 9/16	1 15/16

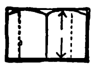
PROPORTIONS FOR SELLERS' STANDARD NUTS AND BOLTS.



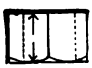
Rough Nut = one and one-half diameter of bolt + $\frac{1}{8}$.



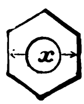
Finished Nut = one and one-half diameter of bolt + $\frac{1}{16}$.



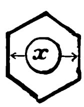
Rough Nut = diameter of bolt.



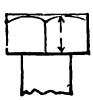
Finished Nut = diameter of bolt—$\frac{1}{16}$.



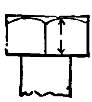
Rough Head = one and one-half diameter of bolt + $\frac{1}{8}$.



Finished Head = one and one-half diameter of bolt + $\frac{1}{16}$.



Rough Head = one-half distance between parallel sides of head.



Finished Head = diameter of bolt—$\frac{1}{16}$.

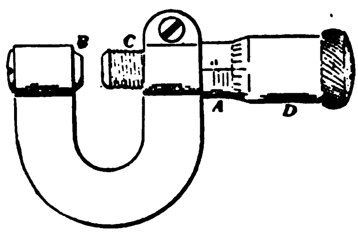
SQUARE BOLT HEADS.

In 1899 the following dimensions for square bolt heads were adopted as standard:

The side of the head shall be one and one-half times the diameter of the bolt, and the thickness of the head shall be one-half the side of the head.

SHEET METAL GAUGE.

At the convention of 1882 the Brown & Sharpe micrometer gauge shown below was adopted as standard for the measurement of sheet metal (see page 132, report 1882). Reaffirmed 1891 (see pages 160, 161, report 1891).



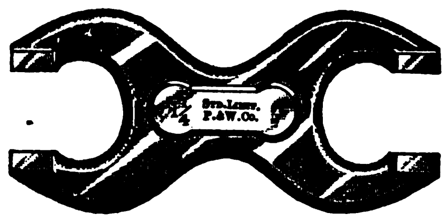
DISTANCE BETWEEN BACKS OF FLANGES.

At the convention of 1884 a motion prevailed that the standard distance between the backs of tires for tender locomotive truck and driving wheels be not less than 4 feet 5⅛ inches, nor more than 4 feet 5½ inches. (See page 26, report 1884.) Modified in 1903. See report of Committee on Revision of Standards.

LIMIT GAUGES FOR ROUND IRON.

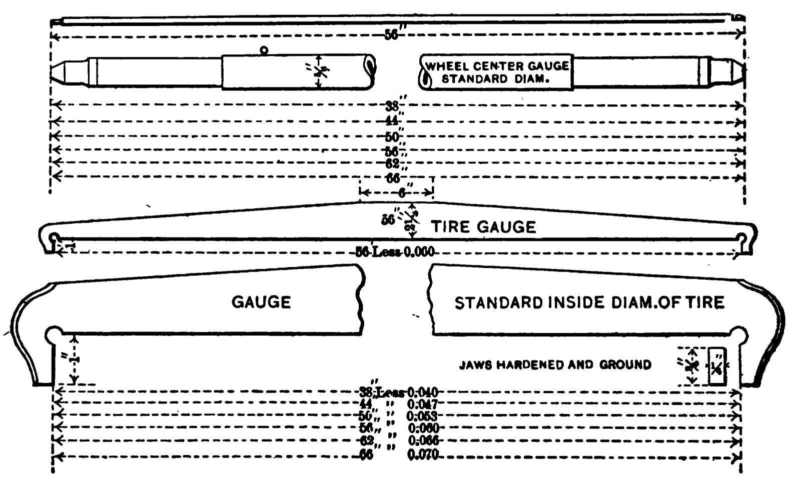
At the convention of 1884 the Pratt & Whitney limit gauges for round iron, shown below, were adopted as standard. (See page 168, report 1884.) Reaffirmed 1891 (see pages 160, 161, report 1891).

Nominal Diameter. Of Iron. Inches.	Large Size, End. Inches.	Small Size, End. Inches.	Total Variation. Inches.
¼	.2550	.2450	.010
5/16	.3180	.3070	.011
⅜	.3810	.3690	.012
7/16	.4440	.4310	.013
½	.5070	.4930	.014
9/16	.5700	.5550	.015
⅝	.6330	.6170	.016
¾	.7585	.7415	.017
⅞	.8840	.8660	.018
1	1.0095	.9905	.019
1⅛	1.1350	1.1150	.020
1¼	1.2605	1.2395	.021



DRIVING WHEEL CENTERS AND SIZES OF TIRES.

At the convention of 1886 the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a committee were adopted, making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Connecticut, and here illustrated, standards of the Association.



At the Twenty-sixth Annual Convention the following sizes were adopted as standards for large driving wheels: 70, 74, 78, 82, 86 and 90 inches.

Reaffirmed in 1891 (see pages 160, 161, report 1891).

In 1907, as a result of letter ballot, 72 inches was adopted as a standard size for large driving wheels.

SECTION OF TIRE.

At the convention of 1893 the standard forms of tires shown on Plate 1 were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.

SHRINKAGE ALLOWANCES FOR TIRES.

In 1907, as a result of letter ballot, the following shrinkage allowances were adopted as standard:

For cast-iron and cast-steel centers less than 66 inches in diameter, 1-80 inch per foot in diameter.

For cast-iron and cast-steel centers 66 inches and over in diameter, 1-60 inch per foot in diameter.

SPOKES.

In 1907, as a result of letter ballot, the following standards were adopted:

In order to properly support the rim and resist the tire shrinkage, spokes should be placed from 12 to 13 inches apart from center to center, measured on the outer circumference of the wheel center.

Spokes at crank hub should not be located at center line of wheel, but on either side, so as not to bring a short spoke directly in line with crank-pin hub. Section of spokes at large end to have an area of from

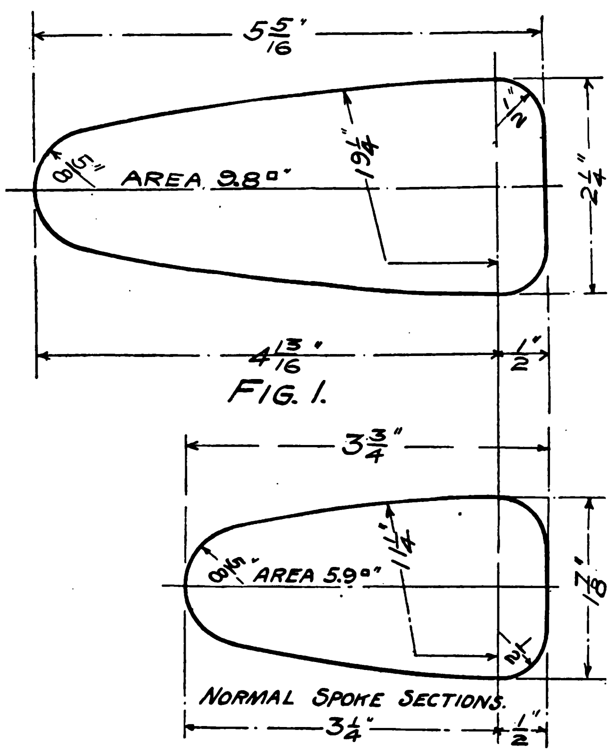


FIG. 2.

9 to 10 inches, with form as shown in Fig. 1. Section of spoke at small end to have an area of from 5¾ to 6 inches, with form as shown in Fig. 2. The sections shown herewith are taken at the base of the fillets uniting the spoke to the hub and rim.

DRIVING-WHEEL CENTERS.

In 1907 the following standards were adopted by letter ballot:

Cast-steel driving-wheel centers should preferably be uncut and shrinkage slots omitted; if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal should be used.

For wheel centers 60 inches and over, when the permissible total weight of the locomotive will allow, the rims should preferably be cast solid without cores, so as to obtain the maximum section and have full bearing of tires; the section in square inches should be approximately .45 of the sectional area of the tire when new.

The section of rim for wheel centers without retaining rings shall be of the form shown below:

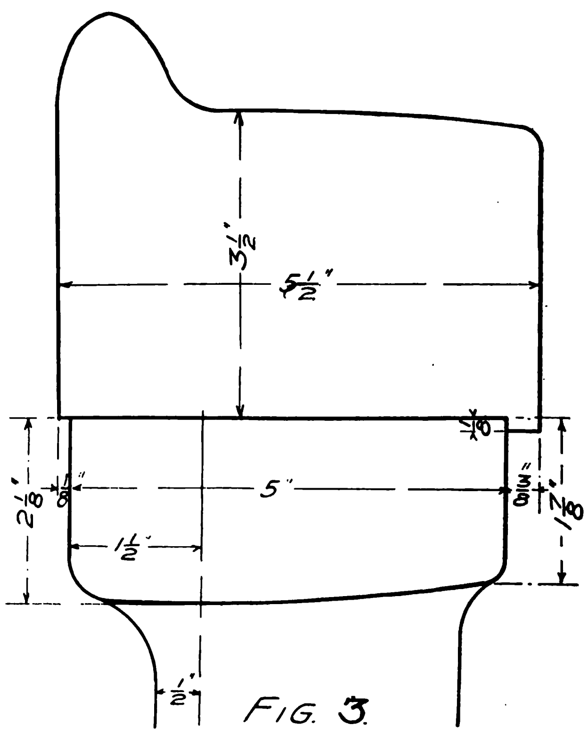


FIG. 3.

The standard distance between hubs shall be 55 inches.

At the convention of 1896 a minimum thickness of 1 inch for the flanges of engine and truck wheels was adopted as standard practice; determination to be made by M. C. B. flange thickness gauge. (See Proceedings for 1896.)

BOILER AND FIRE-BOX STEEL SPECIFICATIONS.

Adopted in 1894. (See pages 68-92, report 1894.) Revised June, 1904.

SPECIFICATION FOR BOILER AND FIRE-BOX STEEL.

MADE BY THE OPEN HEARTH PROCESS.

1. SPECIAL REQUIREMENTS FOR SHELL SHEETS.

This grade of steel is known to the trade as flange or boiler steel. The desired tensile strength is 60,000 pounds per square inch, with minimum and maximum limits 55,000 and 65,000 pounds. The elongation in eight inches shall not be less than twenty-five per cent for sheets three-quarters of an inch thick or under. For thicker sheets, deduct one per cent from specified elongation for each one-eighth inch additional thickness.

2. CHEMICAL REQUIREMENTS FOR SHELL SHEETS.

	Per cent.
Phosphorus shall not exceed (acid)	0.06
Phosphorus shall not exceed (basic)	0.04
Sulphur shall not exceed	0.05
Manganese	0.30 to 0.60

3. SPECIAL REQUIREMENTS FOR FIRE-BOX STEEL.

The desired tensile strength is 57,000 pounds per square inch, with minimum and maximum limits 52,000 and 62,000 pounds. The elongation in eight inches shall not be less than twenty-six per cent.

4. CHEMICAL REQUIREMENTS FOR FIRE-BOX SHEETS.

	Per cent.
Carbon	0.15 to 0.25
Phosphorus shall not exceed (acid)	0.04
Phosphorus shall not exceed (basic)	0.03
Sulphur shall not exceed	0.04
Manganese	0.30 to 0.50

GENERAL REQUIREMENTS.

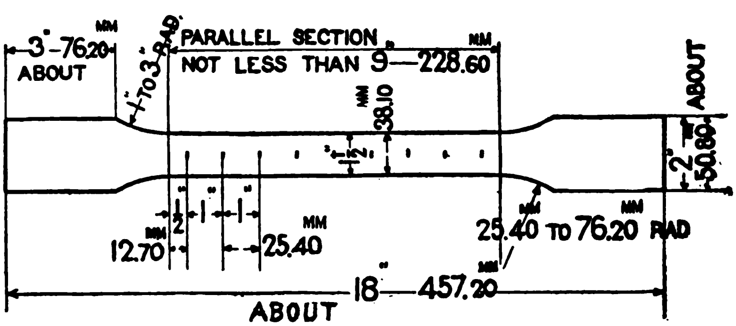
5. BENDING TESTS.

Test specimens for this purpose shall be 1½ inches wide, and for material ¾ inch or less in thickness shall be of the same thickness as that of the finished sheet. For sheets more than ¾ inch thick, the bending-test specimen may be ½ inch thick. The sheared edges of bending-test

specimens may be milled or planed. The cold bending test shall be made on the material in the condition in which it is to be used. The specimen for quench bending test shall be heated to a light cherry red, as seen in the dark, and quenched in water having a temperature between 80° and 90° F. Boiler steel and fire-box steel, before and after quenching, shall bend cold 180° flat on itself without fracture on the outside of the bent portion. The bending test may be made by pressure or by blows. One cold bending specimen and one quenched bending specimen will be furnished from each plate as it is rolled. The homogeneity tests for fire-box steel shall be made on one of the broken tensile test specimens.

6. SPECIMENS FOR TENSILE TEST.

Two tensile test specimens will be furnished from each plate as it is rolled. The standard test specimen of 8-inch gauged length shall be used for the tensile test. The standard shape of the test specimens shall be as shown by the following sketch:



PIECE TO BE OF SAME THICKNESS AS THE PLATE.

7. HOMOGENEITY TEST.

The homogeneity test for fire-box steel is made as follows: A portion of the broken tensile test specimen is either nicked with a chisel or grooved on a machine, transversely about a sixteenth of an inch deep, in three places about two inches apart. The first groove should be made on one side, two inches from the square end of the specimen; the second, two inches from it on the opposite side, and the third, two inches from the last and on the opposite side from it. The test specimen is then put in a vise, with the first groove about a quarter of an inch above the jaws, care being taken to hold it firmly. The projecting end of the test specimen is then broken off by means of a hammer, a number of light blows being used, and the bending being away from the groove. The specimen is broken at the other two grooves in the same way. The object of this

treatment is to open and render visible to the eye any seams due to failure to weld up, or to foreign interposed matter, or cavities due to gas bubbles in the ingot. After rupture, one side of each fracture is examined, a pocket lens being used if necessary, and the length of the seams and cavities is determined. The broken specimen shall not show any single seam or cavity more than ¼ inch long in either of the three fractures.

8. VARIATION IN WEIGHT.

The variation in cross section or weight of more than two and one-half per cent from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations:

Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ per cent variation above or 2½ per cent below the theoretical weight. When 100 inches wide and over five per cent above or five per cent below the theoretical weight.

Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following:

Up to 75 inches wide, 2½ per cent above or 2½ per cent below the theoretical weight. Seventy-five inches wide up to 100 inches wide, five per cent above or three per cent below the theoretical weight. When 100 inches wide and over, ten per cent above or three per cent below the theoretical weight.

For all plates ordered to gauge there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table:

9. TABLE OF ALLOWANCES FOR OVERWEIGHT FOR RECTANGULAR PLATES WHEN ORDERED TO GAUGE.

Plates will be considered up to gauge if measuring not over 1-100 inch less than the ordered gauge.

The weight of 1 cubic inch of rolled steel is assumed to be 0.2833 pound.

PLATES ¼ INCH AND OVER IN THICKNESS.

Thickness of plate	Width of plate.			
Inch.	Up to 75 inches. Per Cent.	75 to 100 inches. Per Cent.	Over 100 inches. Per Cent.	Over 115 inches. Per Cent.
1/4	10	14	18	....
5/16	8	12	16	....
3/8	7	10	13	17
7/16	6	8	10	13
1/2	5	7	9	12
9/16	4 1/2	6 1/2	8 1/2	11
5/8	4	6	8	10
Over 5/8	3 1/2	5	6 1/2	9

PLATES UNDER ¼ INCH IN THICKNESS.

Thickness of plate. Inch.	Width of plate. Up to 50 inches. Per cent	50 inches and above. Per cent.
1/8 up to 5/32	10	15
5/32 " 3/16	8 1/2	12 1/2
3/16 " 1/4	7	10

10. BRANDING.

Each sheet shall be stamped with the melt number and maker's name, and the test specimens cut from it shall be stamped with separate identifying marks or numbers, as may be specified by the purchaser.

11. INSPECTION.

The inspector, representing the purchaser, shall have all reasonable facilities afforded to him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications.

STANDARD METHOD OF CONDUCTING EFFICIENCY TESTS OF LOCOMOTIVES.

In 1894 a method of conducting tests of locomotives was submitted by a committee of the Association, and on motion adopted as a standard of the Association. (See page 200, report 1894.)

The tests are as follows:

*A. Preparations for Test and Location of Instruments.**

1. The locomotive should be put in good condition preparatory to the test. The boiler and tubes should be tight, and both the interior and exterior surfaces should be clean, and, if possible, free from scale. There should be no lost motion in the valve gear, and the valves should be set properly. No change in the engines should be allowed during the progress of a series of tests, unless so ordered for the purposes of the trial.

A glass water-gauge should be fitted to the boiler, if not already provided, and side of it there should be a graduated scale to assist in correcting water quantities, caused by change of inclination of the boiler, and difference of levels when beginning and ending a test. The notches on the quadrant should be marked by large figures, so that they can be read by the cab assistant. The throttle valve lever should be provided with a scale so as to show the degree of opening of the throttle valve.

The point of cut-off of the valves should be determined for each notch in the quadrant.†

* The directions here given apply largely to both shop and road tests, but especially the latter.

† See appendix for description of valve diagram apparatus used on Norfolk & Western Railway.

2. The valves and pistons should be tested for leakage with the engine at rest. The steam valve can be tried by setting the engine so that the valve on one side will be at the center of its throw, in which position both ports are usually covered, and pulling open the throttle valve, blocking the drivers if there is a tendency for the engine to be set in motion. Leakage of the valve, if any occurs, will show itself by escaping at the open cylinder cocks. The tightness of the piston may be tested by setting the engine so that it makes steam, blocking the drivers and opening the throttle valve. This should be tried first on one cylinder and then on the other, and, if desired, it may be tried with the pistons at various points in the stroke. The leakage, if any occurs, will be shown at the open cylinder cock.

3. The following instruments should be verified or calibrated: Steam gauges, draft gauge, pyrometer, thermometers for calorimeter and feed-water, water meter, tank, revolution counter, indicator springs, dynamometer springs and dynamometer recording mechanism. The radiation loss on the steam calorimeter should be determined, or the normal readings ascertained,* and the quantity of steam which passes through the instrument in a given time should be measured.

4. The quantities of steam used by the various auxiliaries of the locomotive can be determined by noting the change in weight of the engine standing upon scales while they are each in use under the usual conditions for known times. Similarly leakage of water and steam can be determined. The quantities can then be properly deducted from the total water used.

5. To facilitate the measurement of coal and the determination of the quantity used during any desired period of the run, it is desirable to provide a sufficient number of sacks of a size holding a weight of, say, 100 pounds, and weigh the coal into these sacks preparatory to starting on the test. If desired, the sacks may be numbered to facilitate the accuracy of record.

6. The instruments and other apparatus that should be provided and their locations are as follows:

To facilitate the work of operating the indicators and reading the instruments at the front end, the smoke-box should be surrounded with a wooden fence, or "pilot-box," as it may be called, resting on the top of the cow-catcher, and extending back far enough to inclose also the sides of the cylinders. This box is floored over above the cylinder heads, and the inclosure thus provided forms a convenient place for the accommodation of the assistants at this end of the locomotive, and it affords them some measure of protection against wind and rain, as also the joltings and vibrations due to rapid travel.

A special steam-gauge with a long siphon is to be used for registering the boiler pressure. It can best be located on the left-hand side of the cab.

The indicator apparatus which is most suitable consists of a three-way cock for the attachment of the indicators, and some form of pantagraph

or other correct reducing motion for the driving rig. The pipes leadii from the cock to the cylinder should be ¾ inch diameter inside, and th should connect into the side of the cylinder rather than into the tv heads. The indicator should also be piped so that a steam-chest diagra can be drawn by it, and from this the steam-chest pressure determine Sharp bends in the pipe should be avoided, and they should be w covered, to intercept radiation. The three-way cock should be provid with a clamp rigidly secured to the cylinder, and thus overcome a tendency of the indicators to move longitudinally with reference to t driving rig. Absolute rigidity is highly essential in this particular. Tv forms of pantagraph motion are shown in Figs. 1 and 2. In both of the the reduced motion is transmitted to the indicator through a light rc working horizontally. By this means a cord eight or ten inches in leng is sufficient for connection to the indicator. Care should be taken to set t instrument in such a position that the cord pin in the end of the r travels in a direction pointing to the groove in the paper drum. Pant graph motions arranged as noted are preferable to the common pendulu and quadrant reducing mechanism, with its long stretch of cord. F another type of correct reducing motion see appendix.

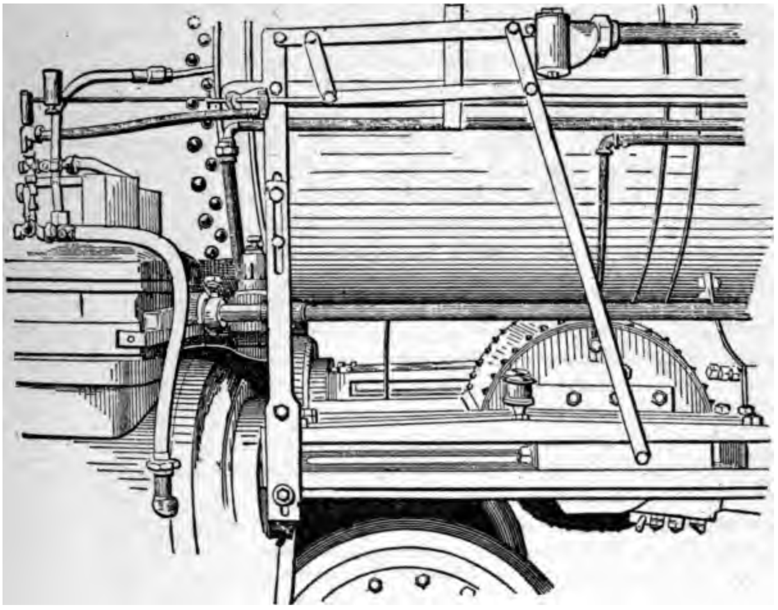
A draught gauge consisting of a U tube containing water, proper graduated in inches, should be placed in the cab and connected to tl smoke-box by a ⅜-inch pipe. This long pipe steadies the water, and t readings can be taken by the cab assistant.

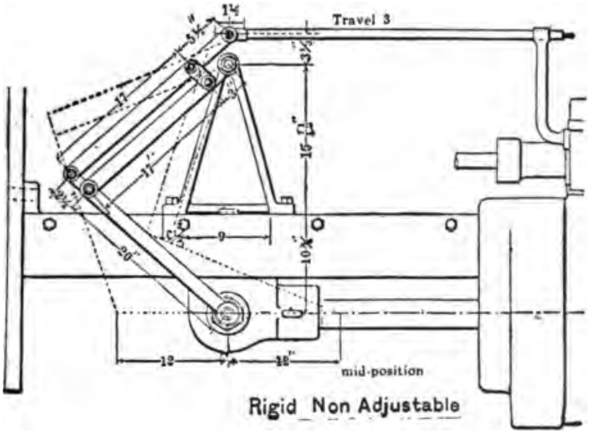
A pyrometer for showing the temperature of the escaping gas should be used in a position below the tip of the exhaust nozzles.

The calorimeter should be attached either to the steam dome a point close to the throttle opening or to the steam passages in the sad casting on one side, according as it is desired to obtain the character the steam at one point or the other. The former location is preferred the committee. A perforated ½-inch pipe should be used for samp and conveying the steam to the calorimeter pipe. For descriptions various forms of calorimeters which are adapted to locomotive use, Trans. A. S. M. E., Vol. X, page 327; Vol. XI, page 790; Vol. XII, 825.

The water meter should be attached to the suction pipe of the jector, and located at a point where it can be conveniently read when locomotive is running. It should be provided with a check valv prevent hot water from flowing back to it from the injector and a stra to intercept foreign material.

To measure the depth of the water in the tank a metallic float sho be used carrying a vertical tube which slides upon a graduated rod, lower end of which rests upon the bottom of the tank. This should placed at the center of gravity of the water space. If the desired locati can not be used, provision should be made for ascertaining the level c inclination of the tank. The best device for this purpose is a plumb lin of a certain known length, provided at the bottom with a double horizon-




Travel 3
mid-position
Rigid Non Adjustable

tal scale having one set of divisions parallel to the side of the tank and the other set at right angles to it. From the readings on these scales referred to, the length of the line, the level of the tank in both directions can be ascertained. A similar device should be attached to the boiler to correct for the variation of its inclination.* The plumb line may be conveniently attached for this purpose at some point near the front end.

The revolution counter should be placed near the front end of the engine, in plain view of the pilot-box. It is operated through a belt from the driver axle. This recommendation applies to that form of counter which shows at a glance the exact speed in revolutions per minute.

A stroke counter should be provided for showing the number of strokes made by the air-pump.

Electric connection should be made between the dynamometer car and cab, so that dynamometer records and indicator diagrams may be taken simultaneously. Another desirable provision is a speaking-tube leading from the dynamometer car to the locomotive cab, and one also to the pilot-box.

7. It is needless, except for a complete record of directions for preparatory work, to call attention to the desirability of having the test, and especially the road test, made under the supervision of a competent person, who is not only familiar with the details of the testing, but also with the proper method of firing and mechanical operation of the locomotive. This is a most important factor, for it is only the clear-headed and able experimenter who is likely to obtain satisfactory work in this most difficult department of engineering tests.

The conductor of the test is best able to determine the number of assistants required, the various duties of the men, and the manner of making records. In general, three (3) men are sufficient to conduct a locomotive test, one (1) being at each cylinder, and one (1) in the cab for taking records.

The men at the cylinders will take indicator diagrams, and one will read the revolution counter and the pyrometer. The indicator papers will be numbered in consecutive order for each cylinder before the test begins, and when the diagram is taken the papers will be deposited through a slot in a box near each assistant.

The cab assistant notes the time of leaving and arriving at stations, the position and time of opening and closing the throttle, the time of taking indicator diagrams, for which he shall determine the time and give the signal by any effective means; the time of blowing off, the time the blower is applied, the number of applications of the injector, the position of the reverse lever, the steam pressure, the draught gauge, the time of passing important stations, the readings of the water glass, meter and air-pump counter, the number of sacks of coal used, the reading of the tank float, the temperature of the feed-water and atmosphere, the direc-

* See appendix for description of special devices used on the Norfolk & Western Railway for this purpose.

tion and force of the wind, the condition of the rail and state of the weather. Many of these readings are as nearly as possible simultaneous with the signal for taking indicator diagrams, and one experienced man in the cab will have no difficulty in entering all of these records in a note-book properly prepared with ruled columns and headings. In case of short stops at stations, one of the men at the indicators can take the tank float observations, or any observation that is advisable at stations. The weights of coal placed upon the tender have been checked by these two persons when weighing it out to the engine. One man takes the level of the boiler at stopping-places where this is required.

When the calorimeter and smoke-box gas samples are used another assistant is required.

In the dynamometer car two (2) men are required, who record the time of each start and stop, the time of passing each station and mile-post, time of taking each indicator diagram as obtained from the signal given by the cab assistant, and all these events are marked on the dynamometer paper. These men, as well as one of the engine assistants, will note the direction and force of the wind, the temperature of the atmosphere and condition of the weather.

8. It is of great importance, after the preparatory work has been accomplished, that a preliminary run be made with the locomotive, in order to fairly test the apparatus and to accustom the men to their duties.

B. The Dynamometer Car.

With a suitable dynamometer car the force required to move the train, or the pull upon the drawbar, is registered upon a strip of paper traveling at a definite rate per mile. The scale upon which this diagram is drawn should be as large as is possible within reasonable limits. A scale of ¼ inch per 1,000 pounds pull is suitable, as the maximum registered pull rarely exceeds 30,000 pounds.

The height of the diagram should be measured from a base line drawn upon the paper by a stationary pen, so located that when no force is exerted upon the drawbar the base line should coincide with zero pull.

The apparatus should be arranged to make a record of time marks in connection with the curve showing the pull. A chronometer should be provided having an electric circuit-breaker, by means of which a mark is made on the dynamometer paper every five (5) seconds. A better apparatus may be used in which a continuous speed curve is traced upon the paper parallel to the curve of pull. The ordinates of this curve, measured from a base line, give the speeds desired.

The location of mile-posts and other points along the route should be fixed upon the dynamometer paper by employing an additional pen, and operating it by means of electric press buttons, which are placed at convenient points in the car.

As already noted, a similar device should be provided for marking upon the dynamometer paper the time of taking indicator diagrams.

The rate of travel of the paper per mile should be such that one inch measured upon the diagrams represents 100 feet for short-distance work, and for long-distance work ½ inch to ¼ inch should be used to represent 100 feet of track. The driving mechanism for the paper should be so arranged that it can be changed to give these three proportions. It is necessary to have all the registering pens located upon the same transverse line at a right angle with the direction of the movement of the paper in order that simultaneous data may be recorded.

C. Method of Conducting the Road Test.

The locomotive having been brought to the train, the steam pressure being at or near the working point, the fire being clean and in good condition, the ash-pan being also clean, observations are taken, say, five (5) minutes before starting time, of the thickness and condition of the fire, the height of water in the boiler, the depth in the tank, the levels, the water meter and the air-pump counter, and thereafter the regular observations are carried forward, and coal is fired from the weighed sacks.

Indicator diagrams should be taken as frequently as possible, the intervals between them being not over two minutes.

Other regular observations should be taken at close intervals. Calorimeter readings, when taken, should be continued for at least five (5) minutes at one minute intervals.

At water stations careful records should be obtained of water heights and levels of boiler and tank.

As the end of the route is approached, the fire should be burned down so as to leave the same amount and the same condition as at the start. When the end is finally reached the fire should be raked and its condition carefully noted. If it differs from that which obtained at the beginning, an estimated allowance must be made for such difference.

At the close of the test the height of water in the boiler should be the same as at the beginning, or, if not, the difference, corrected for inclination of the boiler, should be allowed for.

During the process of weighing the coal into the sacks numerous samples should be obtained and placed in a covered box, and a final sample of these selected. This is to be dried and subjected to chemical analysis and calorimeter test. The sample is weighed before and after drying, and data obtained for determining the weight of dry coal used during the test. The temperature of the feed-water can be best taken at the tank cock, in order to obtain that of a mixed sample.

The duration of the road test is the length of time which the throttle valve is open.

D. The Data and Results.

The data and results of the road test may be tabulated in the form given in Table No. 1. This form corresponds in general with that recommended for shop test, namely, Table No. 2.

TABLE No. 1.

Data and Results of Road Test on....Engine, Made....189 .

General dimensions, etc. (to be accompanied by a complete description of engine with drawings and dimensions, also of train and route):

1. Kind of engine ....
2. Size of cylinders..
3. Clearance of cylinders ....per cent
4. Area of heating surface ....sq. ft.
5. Area of grate surface.......................................sq. ft.
6. Size of exhaust nozzles ....inches
7. Average weight of locomotive and tender (including water)....tons
8. Number of cars ....
9. Weight of cars ....tons
10. Length of route ....miles
11. Number of ton-miles of train load ....ton-miles
12. Number of ton-miles of total load........................ton-miles
13. Schedule time of trips...

Total Quantities.

14. Duration or time throttle valve is open ....hours
15. Weight of dry coal burned ....lbs.
16. Weight of water evaporated, corrected for moisture in the steam and loss at injector*..................................lbs.
17. Weight of ashes and refuse taken from ash-pan..................lbs.
18. Weight of cinders from smoke-box ....lbs.
19. Percentage of ash as found by coal calorimeter test..........per cent
20. Total heat of combustion as found by calorimeter test ....B. T. U.
21. Results of chemical analysis of coal ....

Power Data.

22. Mean effective pressure, H. P. cyls.............................lbs.
23. Mean effective pressure, L. P. cyls.............................lbs.
24. Average revolutions per minute................................rev.
25. Indicated horse-power, H. P. cyls...........................H. P.
26. Indicated horse-power, L. P. cyls............................H. P.
27. Indicated horse-power, whole engine.........................H. P.
28. Pull on drawbar...lbs.
29. Dynamometer horse-power ....H. P.

Averages of Observations of Instruments.

30. Average boiler pressure ....lbs.
31. Average steam-chest pressure ....lbs.
32. Average temperature of smoke-box............................ °
33. Average drought suction... "

* Should be corrected for steam used by calorimeter, air-pump, blower, safety valve and whistle, to find cylinder results — line 56.

34. Average temperature of feed-water............................. °
35. Average temperature of atmosphere............................ °
36. Average percentage of moisture in the steam.................per cent
37. Maximum percentage of moisture in the steam.............per cent
38. Weather, wind, etc..

Other Data.

39. Average position of throttle..
40. Average position of reversing lever...............................
41. Average speed in miles per hour..................................
42. Maximum speed in miles per hour................................
43. Number of stops..
44. Average number of strokes of air pump per minute.................
45. Total estimated weight of steam used by air pump per hour......lbs.
46. Estimated loss of steam at safety valve per hour..................lbs.
47. Estimated loss of steam at whistle per hour.......................lbs.
48. Estimated weight of steam used by blower per hour...............lbs.
49. Estimated loss of steam at calorimeter per hour..................lbs.

Hourly Quantities.

50. Weight of dry coal burned per hour.............................lbs.
51. Weight of dry coal burned per hour per square foot of grate surface ....lbs.
52. Weight of coal burned per square foot of heating surface.........lbs.
53. Weight of water evaporated per hour...........................lbs.
54. Equivalent weight of water evaporated per hour with feed-water at 100° and pressure 70 lbs...........................lbs.
55. Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface...........................lbs.
56. Weight of water consumed by engine cylinder (line 53, less sum of lines 45, 46, 47, 48 and 49)..........................lbs.

Principal Results — Complete Engine and Boiler.

57. Coal consumed per I. H. P. per hour............................lbs.
58. Coal consumed per dynamometer horse-power per hour...........lbs.
59. Coal consumed per ton-mile of train load........................lbs.
60. Coal consumed per ton-mile of total load........................lbs.
61. Weight of standard coal consumed per I. H. P. per hour.........lbs.
62. Weight of standard coal consumed per dynamometer horse-power per hour...lbs.
63. Weight of standard coal consumed per ton-mile of train load....lbs.
64. Weight of standard coal consumed per ton-mile of total load.....lbs.

Boiler Results.

65. Water evaporated per pound of coal ....lbs.
66. Equivalent evaporation per pound of coal from and at 212°......lbs.

67. Equivalent evaporation per pound of combustible from and at 212° ....lbs.

58. Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units..

Cylinder Data.

9. Mean initial pressure above atmosphere..........................lbs.

	H. P. Cyl.	L. P. Cyl.
Cut-off pressure above zero...............lbs.	......	......
Release pressure above zero ....lbs.	......	......
Compression pressure above zero..........lbs.	......	......
Lowest back pressure above or below atmosphere ....lbs.	......	......
Proportion of forward stroke completed at cut-off	......	......
Proportion of forward stroke completed at release	......	......
Proportion of return stroke uncompleted at compression	......	......
Mean effective pressure (lines 22 and 23) lbs.	......	......

Cylinder Results.

Total water consumed per indicated horse-power per hour, corrected for moisture in steam............................lbs.

Water consumed per I. H. P. per hour by cylinders alone (from line 56)..lbs.

	H. P. Cyl.	L. P. Cyl.
Steam accounted for by indicators at cut-off.lbs.	......	......
Steam accounted for by indicator at release.lbs.	......	......
2. Proportion of feed-water used by cylinders (line 79) accounted for at cut-off............	......	......
3. Proportion of feed-water used by cylinders accounted for at release..................	......	......
4. Total heat supplied by boiler to cylinders per hour in British thermal units...........	......	......
5. Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units.....................	......	......
6. Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units	......	......

The following form for the tabulation of the results of locomotive tests will be found convenient. They can, of course, be modified to suit any method of testing, whether standard or not:

LOCOMOTIVE TESTS — GENERAL RESULTS.

..................................*Railroad Co.*
................*Tests of Locomotive No*......, *between*................
and............................*Distance*......*Miles. Train No*........
................*Bound.* ...., *18*....
Kind of Coal............................ *Coal Analysis*.............
Calorimetric Value of Coal..

Trip No..
Date ....
Left ....at...
Arrived ....at...
Left ....at...
Arrived ....at...

1. Weather ....
2. Mean temperature of atmosphere...................................
3. Direction of wind...
4. Velocity of wind, miles per hour..................................
5. Condition of rails..
6. Weight of train in tons of 2,000 lbs., including locomotive, tender, passengers and freight.....................................
7. Weight of train in tons of 2,000 lbs., excluding the locomotive and tender ....
8. Equivalent number of standard cars at ....tons each.........
9. Size of exhaust nozzle, single or double..........................
10. Maximum boiler pressure by gauge.................................
11. Minimum " " " " ....
12. Average " " " " ....
13. Prevailing position of throttle (wide open = 1.00)...............
14. " " " reverse lever (notch) ....
15. " points of cut-off ....
16. Schedule time in motion..
17. Actual " " " ....
18. Time made up in minutes..
19. Aggregate intermediate stops, minutes............................
20. Time during which power was developed, or throttle open..........
21. Maximum number of revolutions per minute.........................
22. Minimum number of seconds per mile...............................
23. Maximum rate of speed, miles per hour............................
24. Average speed, miles per hour....................................
25. Actual weight of coal fired......................................

Moisture in coal, percentage..

Dry coal fired...

Actual weight of wood used..

Total weight of coal fired (wood added at .4)......................

Weight of refuse in fire-box and ash-pan..........................

" **unconsumed coal recovered from fire-box and ash-pan**.......

Total weight of coal consumed (Item 29-31)......................

Net weight of ashes in fire-box and ash-pan.........................

Weight of cinders (sparks) in smoke-box...........................

Percentage of ash in coal...

" " cinders (sparks)..

" " total refuse...

Percentage of combustible consumed...................................

Weight of combustible utilized..

Number of miles run per ton (2,000 lbs.) of coal.......................

" " pounds of coal used per mile.......................................

Coal used per ton of train per 100 miles...............................

" " " car-mile..

Average weight of coal burned per square foot of grate surface per hour ....

Total coal per indicated horse-power developed per hour............

Average temperature of feed-water.....................................

Weight of water drawn from tender.....................................

Waste of injector, leakage, etc..

Weight of water apparently evaporated (Item 47-48)................

Percentage of moisture in steam.......................................

Water actually evaporated, corrected for quality of steam............

Actual evaporation per pound of total coal.............................

Equivalent evaporation from and at 212° per pound of coal........

" " " " " " " " combustible.

Water used per ton of train per 100 miles.............................

" " " car-mile ....

" " " hour while developing power....................................

" " " indicated horse-power per hour..................................

" " " sq. ft. of heating surface, from and at 212°..................

" " " " " " grate " " " " ....

Maximum indicated horse-power developed............................

Average " " " ....

3. Dry steam used per indicated horse-power, per hour, per indicator diagram ....

Average number of sq. ft. of heating surface per indicated horse-power

Average number of indicated horse-power per sq. ft. of grate surface.

Prevailing temperature in smoke-box while using steam.............

" draft in smoke-box while using steam, in inches of water.

SHOP TEST.

A. Preparation and Location of Instruments.

In preparing for a shop test the preparations described for the road test should be followed so far as the nature of the test requires. When run as a stationary engine the locomotive is not circumscribed by the conditions of road service, and many provisions required on the road are unnecessary. It is unnecessary to determine the quantity of steam consumed by the air pump and auxiliaries, for these are not brought into use on the shop test; and no occasion exists for finding the quantity lost at the safety valve, for on the continuous shop run the steam pressure can be maintained at a uniform point, and blowing off readily prevented. It is unnecessary to use sacks for the convenient measure of coal, because the coal can be readily weighed up in lots as fast as needed for the test. It is unnecessary to provide a "pilot-box," and no fixed location of the instruments is required, as on the road test. The feed-water may be weighed before it is supplied to the tank, and the tank may be used in this case as a reservoir, the float showing its depth. The meter would thus be unnecessary as the principal instrument of measurement, but a meter is in all cases useful as a check upon this most important element in the data. The long indicator pipes required on the road test may be dispensed with, and one indicator applied close to each end of the cylinder, a practice much to be preferred to the use of a three-way cock and the single indicator. The dynamometer car is not required, but its equivalent should be provided, consisting of a dynamometer which registers the pull on the drawbar in the same manner as the device used on the road.

The number of assistants required on a shop test is less than that needed for a road test. A good test can be made with four (4) assistants, distributed as follows:

One assistant for operating indicators.

One assistant for measuring water.

Two (2) assistants for general observations and coal measurement.

B. Conditions of Test.

The test should be continued for a run of at least two (2) hours from the time normal conditions have been established.

At the close of the test the water height in the boiler and the height of water in the tank should be the same as at the beginning, or proper corrections made for any differences which may exist.

The fire-box and ash-pit are then cleaned, and such unburnt coal as may be contained in the refuse is separated, weighed and deducted from the total weight of coal fired. The balance of the refuse is weighed, as also the cinders removed from the smoke-box.

During the progress of the test samples of the various charges of coal should be obtained, and at its close a final sample of these should be selected, dried and subjected to chemical analysis and calorimeter test.

he weight of the sample as taken before and after drying to ascertain ie weight of moisture contained in the fuel.

C. The Data and Results.

The data and results of the shop test can best be arranged in the anner indicated in Table No. 2. So far as these are in common with ie data and results obtained on the road test, the forms used on both nds of test are identical.

TABLE No. 2.

*Data and Results of Shop Test on....Engine, made......*189......

General dimensions, etc. (to be accompanied by a complete description, ith drawings and full dimensions).

Kind of engine..

Size and clearance of cylinders....................................

Area of heating surface...

Area of grate surface...

Diameter of exhaust nozzles.......................................

Total Quantities.		Whole Run.
Duration	hrs.	......
Weight of dry coal burned, including .4 weight of wood.	lbs.	......
Weight of water evaporated corrected for moisture in the steam	lbs.	......
Weight of ashes and refuse from ash-pan..............	lbs.	......
Weight of cinders from smoke-box..................	lbs.	......
Percentage of ash as found by calorimeter test....	per cent	......
Total heat of combustion per lb. coal as found by calorimeter test.............................	B. T. U.	......
Power Data.		
Mean effective pressure, high-pressure cylinders......	lbs.	......
Mean effective pressure, low-pressure cylinders........	lbs.	......
5. Average revolutions per minute.....................	rev.	......
6. Indicated horse-power, high-pressure cylinders.....	H. P.	......
7. Indicated horse-power, low-pressure cylinders.......	H. P.	......
18. Indicated horse-power, total........................	H. P.	......
19. Pull on drawbar	lbs.	......
20. Dynamometer horse-power	H. P.	......
Averages of Observations.		
21. Average boiler pressure............................	lbs.	......
22. Average steam-chest pressure........................	lbs.	......
23. Average temperature of smoke-box...................	°	......
24. Average draught suction...........................	"	......
5. Average temperature of feed-water	°	......
6. Average temperature of atmosphere...................	°	......
7. Average percentage of moisture in the steam....	per cent	......
8. Maximum percentage of moisture in the steam...	per cent	......

Hourly Quantities.

Whole

29. Weight of dry coal burned per hour..................lbs. ...
30. Weight of dry coal burned per hour per square foot of grate surface..................................lbs. ...
31. Weight of coal burned per hour per square foot of heating surface..................................lbs. ...
32. Weight of water evaporated per hour................lbs. ...
33. Equivalent weight of water evaporated per hour with feed-water at 100° and pressure at 70 lbs..........lbs. ...
34. Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface.........lbs. ...

Principal Results, Complete Engine and Boiler.

35. Coal consumed per I. H. P. per hour..................lbs. ....
36. Coal consumed per dynamometer horse-power per hour ....lbs. .....
37. Weight of "standard coal" consumed per I. H. P. per hour ....lbs. .....
38. Weight of "standard coal" consumed for a dynamometer horse-power per hour.....................lbs. .....

Boiler Results.

39. Water evaporated per pound of coal..................lbs. ......
40. Equivalent evaporation per pound of coal from and at 212°..lbs. ......
41. Equivalent evaporation per pound of combustible from and at 212°..............................lbs. ......
42. Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units.................... ......

Cylinder Data.

43. Mean initial pressure above atmosphere.............lbs. ......

	H. P. Cyl.	L. P. Cyl.
44. Cut-off pressure above zero.................lbs.	......	......
45. Release pressure above zero................lbs.	......	......
46. Compression pressure above zero...........lbs.	......	......
47. Lowest back pressure above or below atmosphere ....lbs.	......	......
48. Proportion of forward stroke completed at cut-off	......	......
49. Proportion of forward stroke completed at release	......	......
50. Proportion of return stroke uncompleted at compression	......	......

Cylinder Results.

51. Total water consumed per indicated horse-power per hour corrected for moisture in steam............................lbs.

52. Water consumed per I. H. P. per hour by cylinders alone (from line 51 less all measured losses)......................lbs.

		H. P. Cyl.	L. P. Cyl.
53.	Steam accounted for by indicators at cut-off.lbs.	......	......
54.	Steam accounted for by indicators at release.lbs.	......	......
55.	Proportion of feed-water used by cylinders (line 52) accounted for at cut-off.........lbs.	......	......
56.	Proportion of feed-water used by cylinders accounted for at release ....lbs.	......	......
57.	Total heat supplied by boiler to cylinders per hour in British thermal units.............	......	......
58.	Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units.........................	......	......
59.	Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units......................	......	......

Reports should give a copy of a set of sample indicator diagrams, also combined diagram (in case of compound engines) and a chart showing graphically the principal data.

SUPPLEMENT.

Description of Norfolk & Western Indicator Rigging. Fig. 1, General Arrangement. Fig. 2, Details.

This form of indicator rigging involves the use of a lever (supported from the running-board by a suitable bracket), and connected at its lower end to the cross-head (by a link 12 in. long). The indicator drum cord takes its motion from a square bar working in suitable guides and connected by a short link to the main lever. In order to secure a perfectly parallel motion, the length of the cross-head link should bear the same ratio to the length of the indicator-bar link as the full length of the main lever bears to the distance from fulcrum of main lever to point of connection of the indicator-bar link. For an engine with 24-inch stroke this ratio should be 1 to 6, in order to produce an indicator card 4 inches long, and the long and short links should be 12 inches and 2 inches, respectively.

Description of Valve Motion Indicator. Fig. 3.

In this apparatus a string is wound around the groove on one end of drum, and passed over proper pulleys until it leads off in a line with the motion of the cross-head, and the other end is attached to the cross-head,

so that any motion of the piston is communicated by the cord to the drum, causing corresponding rotation.

A cord from the pen-bar is led over suitable pulleys and attached to valve rod in the same manner. The combination of the two motions, as will be seen, will give an elliptical diagram in which the abscissæ represent the position of the piston, and the ordinates the position of the valve.

Description of Boiler Lever Indicator. Fig. 4.

This apparatus consists of a spirit level mounted in a saddle which slides on an arc of a large circle. This arc is graduated, and should be sufficiently curved to operate on the heaviest grade upon which the engine will be tested.

By putting the engine on jacks or cranes, and giving different elevations to the boiler, the height of water may be measured by means of a meter to certain points on the gauge-glass, and a corresponding table made, which will denote the quantity of water in the boiler for each different angular position of the boiler. These figures can be used to make corrections on the meter readings, allowing for inclinations of the track on which the engine is standing by simply pushing the spirit lever to a horizontal position and noting the reading on the indicator.

SPECIFICATIONS AND TESTS FOR IRON LOCOMOTIVE BOILER TUBES, EXTRA QUALITY.

At the convention of 1895 the following Specifications and Tests for Iron Locomotive Boiler Tubes were adopted as standard (see page 127, report 1895); modified in 1896 (see pages 332, 333, report 1896). Revised, June, 1904.

SPECIFICATIONS FOR IRON LOCOMOTIVE BOILER TUBES.

1. Tubes are to be made of knobbled, hammered charcoal iron, lap-welded.

2. Tubes must be of uniform thickness throughout, except at weld, where an additional thickness of .015 will be allowed. They must be circular within .02 inch, and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch.

3. The minimum weights for tubes of various diameters and thicknesses are given in the following table:

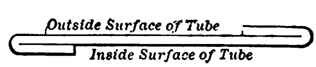
Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1.65
	" 12	.110	1.89
	" 11	.125	2.07
	" 10	.135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.17
	" 11	.125	2.38
	" 10	.135	2.64
2¼ inch	" 13	.095	2.16
	" 12	.110	2.46
	" 11	125	2.70
	" 10	.135	2.99
2½ inch	" 12	.110	2.73
	" 11	.125	3.02
	" 10	.135	3 37

SURFACE INSPECTION.

4. Tubes must have a smooth surface, free from all laminations, cracks, blisters, pits and imperfect welds. They must be free from bends, kinks and buckles, and from evidence of unequal contraction in cooling or injury in manipulation.

PHYSICAL TESTS.

5. Bending Tests.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80° F., shall bend in opposite directions at each end, as shown in sketch below, without cracks or flaws, and when nicked and broken by slight blows, these strips must show a fracture wholly fibrous.



6. Expanding Test.— Sections of tubes 12 inches long shall be heated a length of 5 inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test, care must be taken to see that the end of the tube is smoothly trimmed.

7. One tube is to be tested, as required in paragraphs 5 and 6, in each lot of 250 tubes or less.

8. CRUSHING TEST.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction and without cracking or bending at weld.

9. HYDRAULIC TEST.— Before shipping, each tube must be tested by manufacturer to 500 pounds per square inch, and each tube must be plainly marked in the middle: "Knobbled charcoal, tested to 500 pounds pressure."

10. In addition to the above tests, tubes which, when inserted into boilers, split or break while being expanded or beaded, and also individual tubes which fail to pass surface inspection will be rejected and returned to the makers at their expense.

11. ETCHING TEST.— In case of doubt as to the quality of material, the following test shall be made to detect the presence of steel. A section of tube, turned or ground to a perfectly true surface on the end, will be polished free from dirt or cracks, and the end of the tube will be suspended in a bath of nine parts water, three parts sulphuric acid and one part hydrochloric acid. The bath will be prepared by placing water in a porcelain dish, adding the sulphuric and then the hydrochloric acid. The chemical action must be allowed to continue until the soft parts are sufficiently dissolved so that the iron tube will show a decided ridged surface, with the weld very distinct, while the steel tube will show a homogeneous surface.

SPECIFICATION FOR SEAMLESS, COLD DRAWN STEEL LOCOMOTIVE BOILER TUBES.

1. Tubes are to be cold drawn, seamless and made of open hearth steel. It is desired that the steel from which the tubes are manufactured should have the following chemical composition:

	Per cent.
Carbon	.15 to .20
Manganese	.45 to .55
Sulphur, below	.03
Phosphorus, below	.03

Tubes containing more than .03 phosphorus or sulphur will be rejected.

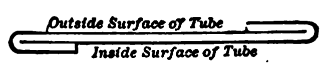
2. Tubes must be of uniform thickness throughout. They must be circular within .02 of an inch and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch. They must be free from bends, kinks and buckles.

3. The minimum weights of the tubes of various diameters and thicknesses are given in the following table:

OUTSIDE DIAMETER.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1.69
	" 12	.110	1.92
	" 11	.125	2.15
	" 10	.135	2.29
2 inch.........................	" 13	.095	1.91
	" 12	.110	2.19
	" 11	.125	2.47
	" 10	.135	2.65
2¼ inch	" 13	.095	2.16
	" 12	.110	2.48
	" 11	.125	2.80
	" 10	.135	3.01
2½ inch	" 12	.110	2.73
	" 11	.125	3.04
	" 10	.135	3.41

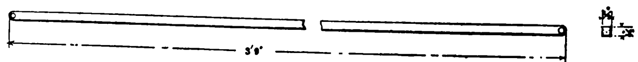
PHYSICAL TESTS.

4. BENDING TEST.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80 degrees F., shall bend in opposite directions at each end, as shown in sketch below without cracks or flaws.

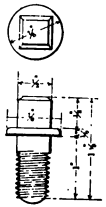


5. EXPANDING TEST.— Sections of tubes 12 inches long shall be heated a length of five inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test care must be taken to see that the end of the tube is smoothly trimmed.

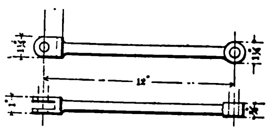
6. CRUSHING TEST.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction.



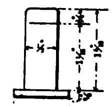
Sliding Bar, Iron. 2 Thus



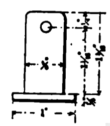
Clamp Screw, Iron. 2 Thus



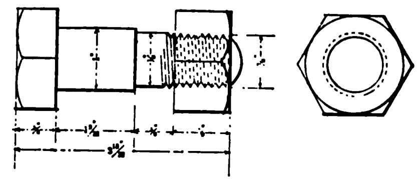
Connecting Rod, Iron. 2 Thus



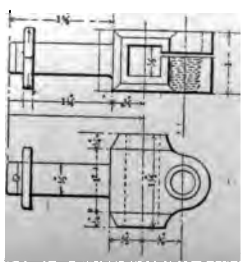
Link Pin, Iron. 2 Thus



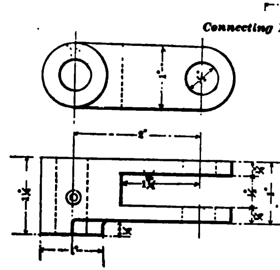
Connecting Rod Pin, Iron. 2 Thus



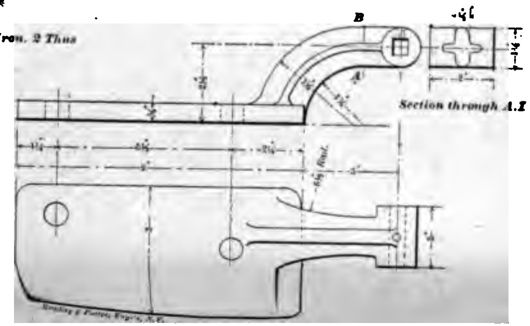
Indicator Lever Bolt, Iron. 2 Thus



Sliding Bar Clamp, Brass. 2 Thus



Connecting Link, Brass. 2 Thus



Sliding Bar Guide, Cast Iron. 4 Thus

6th. The gauge must be plainly stamped with the words "Decimal Gauge" in capital letters .2 inch high, and below this the words "Master Mechanics."

7th. In ordering material, the term gauge shall *not* be used, but the thickness ordered by writing the decimal as in above list. For sizes over ¼ inch, the ordinary common fractions may be used.

BRIGGS STANDARD WROUGHT-IRON PIPE THREADS.

At the convention of 1899, what is known as the Briggs Standard, as determined by the Pratt & Whitney gauges, of threads for wrought-iron pipe and couplings, was adopted as a standard of the Association.

The gauges used by the Pratt & Whitney Company were made by them from an autograph copy of a table made by Mr. Robert Briggs personally, who originally established and published these standard threads. A copy of it is as follows:

STANDARD DIMENSIONS OF WROUGHT-IRON WELDED TUBES. BRIGGS STANDARD.

Diameter of Tube.			Thickness of metal.	Screwed Ends.	
Nominal inside.	Actual inside.	Actual outside.		Number of threads per inch.	Length of perfect screw.
Inches.	Inches.	Inches.	Inch.	No.	Inch.
⅛	0.270	0.405	0.068	27	0.19
¼	0.364	0.540	0.088	18	0.29
⅜	0.494	0.675	0.091	18	0.30
½	0.623	0.840	0.109	14	0.39
¾	0.824	1.050	0.113	14	0.40
1	1.048	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.468	2.875	0.204	8	0.89
3	3.067	3.500	0.217	8	0.95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.982	8.625	0.322	8	1.46
9	9.000	9.688	0.344	8	1.57
10	10.019	10.750	0.366	8	1.68

Tapers of conical tube ends, 1 in 32 to axis of tube. (¾-inch per foot.)

By the late action of the Manufacturers of Wrought-Iron Pipe, 9-inch outside diameter has been excepted from the original list, as above noted, the diameter now adopted being 9.625 instead of 9.688 inches given in the Briggs table.

STANDARD PIPE UNIONS.

At the convention of 1902 standard dimensions for pipe unions ⅛ to 4 inches, inclusive, were proposed for adoption, and, at the convention of 1903, the same were adopted as standard. These dimensions are shown on Table A.

AXLES.

At the convention of 1879 the Master Car Builders' Standard Axle with 3¾ by 7 inch journals was adopted as standard. (See pages 14-35, 52-58, report 1879.) Changed to Recommendations 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. standard 1903. See plate 1.

At the convention of 1890 the Master Car Builders' standard axle with journals 4¼ by 8 inches was adopted as standard. See page 166, report 1890.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. standard in 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with 5 by 9 inch journals was adopted as standard. See report of Committee on Revision of Standards, 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with journals 5½ by 10 inches was made a standard. See report of Committee on Revision of Standards. See also plate 1.

JOURNAL BOX, BEARING AND PEDESTAL.

At the convention of 1881 a design of Journal Box, Bearing and Pedestal, as shown in figs. 1, 2 and 3, was submitted and made standard for cars and locomotive tenders. (See pages 110-115, report 1881.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Changed to standard in 1903. See plate 14.

At the convention of 1903 the M. C. B. journal boxes and contained parts for the 3¾ by 7 inch, 4¼ by 8 inch, 5 by 9 inch and 5½ by 10 inch standard axles, as shown on plate 1, were made a standard of the Association. They are shown on plates 2 to 13, inclusive.

SPECIFICATION FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed .... .05 per cent.
   Sulphur, not to exceed .... .05 per cent.
   Manganese, not to exceed .... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation in two inches — not less than 20 per cent.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half-way between the center and the outside, the hole made by the drill to be not more than 2 inches in diameter nor more than 4½ inches deep. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.)

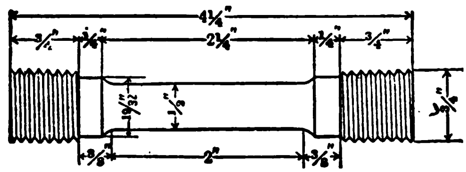


FIG. 1.

Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

5. Each axle must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

6. All axles must be free from seams, pipes and other defects, and must conform to drawings accompanying these specifications.

7. Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers.

8. Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed .... .05 per cent.
Sulphur, not to exceed .... .05 per cent.
Manganese, not to exceed .... .60 per cent.

5. Grade "B":

Carbon	.35 to .50 per cent.
Phosphorus, not to exceed...........	.05 per cent.
Sulphur, not to exceed	.05 per cent.
Manganese, not to exceed...........	.60 per cent.

TESTS.

6. One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

7. Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch, and have order number plainly marked with white lead.

INSPECTION.

8. Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than ½ inch will be rejected.

9. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers.

10. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is intended for rod straps and miscellaneous forgings.

Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

FITTINGS FOR LUBRICATORS.

At the convention of 1906 the Committee on Locomotive Lubrication proposed a standard location of holding arm shoulder and oil and steam connection joint faces; also a system of fittings and joints for all connections. Fig. 1 shows the location for connection of joints and holding arm. Figs. 2, 3, 4 and 5 show pipe joints and fittings, and Fig. 6 illustrates the holding arm proposed.

On reference to letter ballot they were adopted as standard. They are as shown herewith.

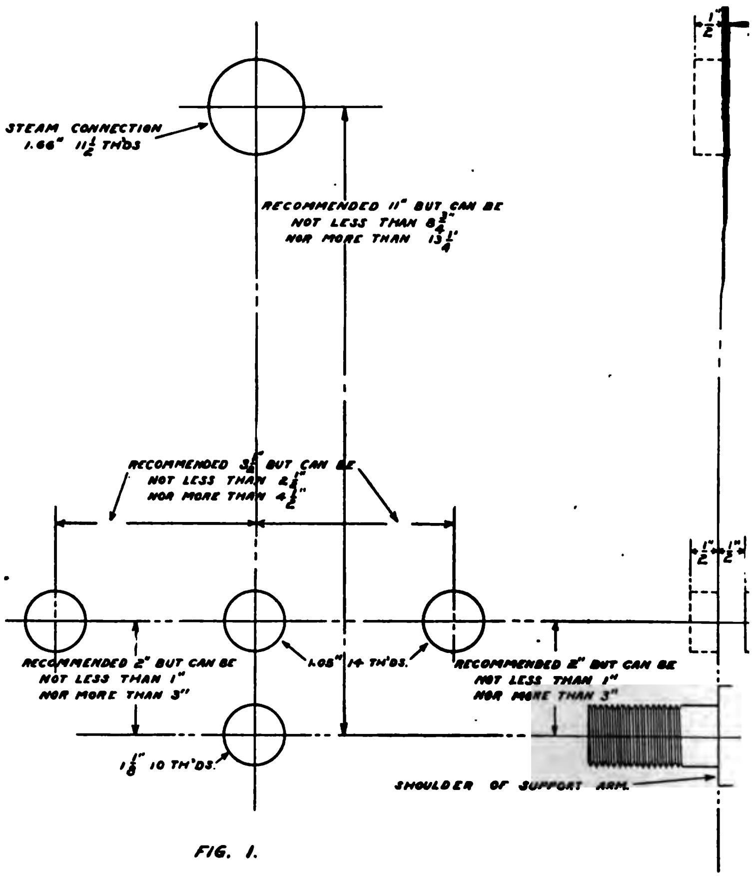

STEAM CONNECTION
1.66" 11½ TH'DS
RECOMMENDED 11" BUT CAN BE
NOT LESS THAN 8¾"
NOR MORE THAN 13¼"
RECOMMENDED 3½" BUT CAN BE
NOT LESS THAN 2½"
NOR MORE THAN 4½"
RECOMMENDED 2" BUT CAN BE
NOT LESS THAN 1"
NOR MORE THAN 3"
1.05" 14 TH'DS.
RECOMMENDED 2" BUT CAN BE
NOT LESS THAN 1"
NOR MORE THAN 3"
1⅛" 10 TH'DS.
SHOULDER OF SUPPORT ARM.

FIG. 1.

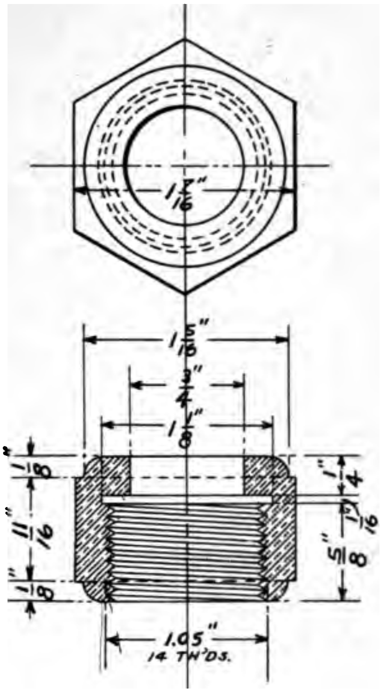


FIG. 2.

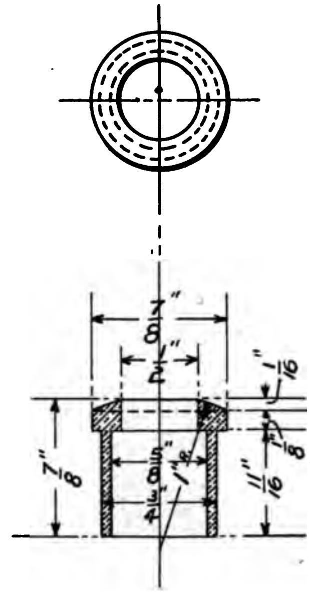


FIG. 3.

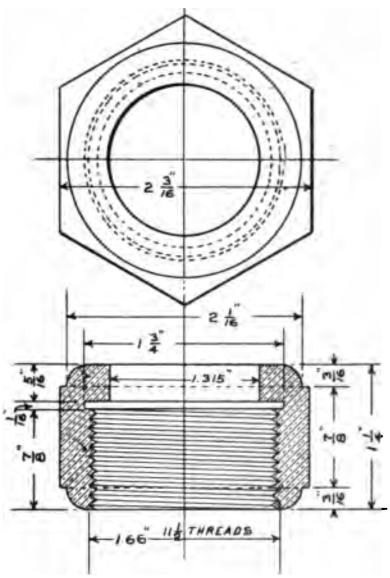


FIG. 4

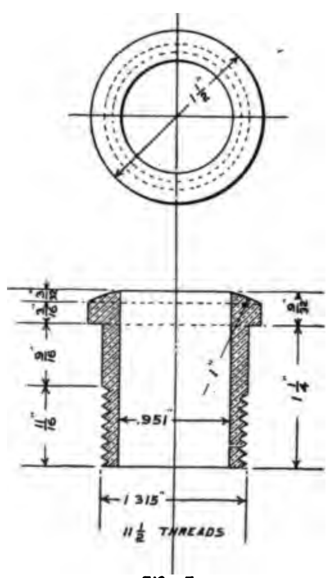


FIG. 5.

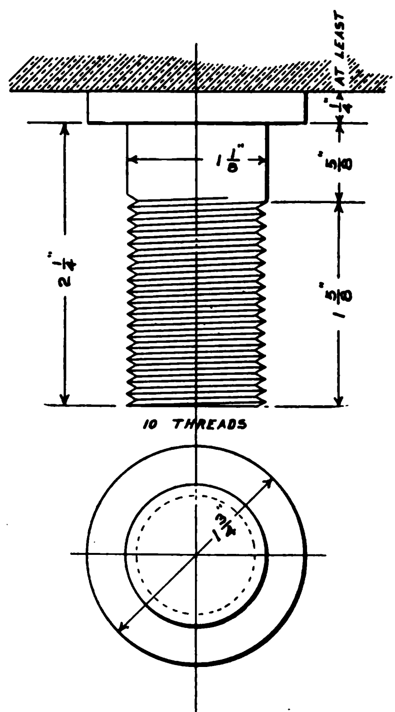


FIG. 6.

SPECIFICATIONS FOR FOUNDRY PIG IRON.

At the convention of 1906 specifications for foundry pig iron were proposed, and on reference to letter ballot were adopted as standard. They are as follows:

The material desired under this specification is an open-grain foundry pig conforming to and graded by the following detail specifications:

Combined carbon	.40 to .70 per cent.
Manganese	.40 to .80 per cent.
Phosphorus	.40 to .80 per cent.
Sulphur, not over	.06 per cent.

The grades are determined by the amount of silicon, in accordance with the attached schedule:

Grade No. 1, silicon....................	3.00 to 2.50 per cent.
Grade No. 2, silicon....................	2.50 to 2.00 per cent.
Grade No. 3, silicon....................	2.00 to 1.50 per cent.
Grade No. 4, silicon....................	1.50 to 1.00 per cent.

Each carload, or its equivalent, shall be considered as a unit. At least one pig shall be selected at random for each four tons of every carload and so as to fairly represent it.

Drillings shall be taken so as to fairly represent the fracture surface of each pig, and the sample analyzed shall consist of an equal quantity of drillings from each pig, well mixed and ground before analysis.

In case of disagreement between buyer and seller, an independent analyst, to be mutually agreed upon, shall be engaged to sample and analyze the iron. In this event one pig shall be taken to represent every two tons.

The cost of this sampling and analysis shall be borne by the buyer if the shipment is proved up to specifications, and by the seller if otherwise.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDER CASTINGS, CYLINDER BUSHINGS, CYLINDER HEADS, STEAM CHESTS, VALVE BUSHINGS AND PACKING RINGS.

At the convention of 1906 the following specifications were proposed, and on reference to letter ballot were adopted as standard:

The material used in such castings must conform to the following specifications:

Silicon	1.25 to 1.60 per cent.
Phosphorus	.50 to .80 per cent.
Sulphur	.06 to .10 per cent.
Manganese	.30 to .60 per cent.
Combined carbon	.50 to .70 per cent.
Graphite carbon	2.75 to 3.25 per cent.

Tensile strength, 25,000 lbs. per sq. inch minimum.

Transverse strength, 3,000 lbs. minimum on 1¼-inch round bar, 12 inches between supports.

Deflection, .10 inch minimum on transverse test.

Shrinkage, ⅛ inch in 1 foot as a maximum.

The quality of the iron going into castings under specification shall be determined by means of the "arbitration bar." This is a bar 1¼ inches in diameter and 15 inches long. It shall be prepared as stated further on and tested transversely. The tensile test is not recommended, but in case it is called for it may be made from any of the broken pieces of the transverse test. The expense of the tensile test shall fall on the purchaser.

The tensile test piece should be prepared with threaded ends, 1¼ inches in diameter, and with a central neck of 0.8 inch diameter, 1 inch between shoulders, with a 7-32-inch radius at the shoulders, the shoulders being 1 inch in diameter and ¼ inch in length to the thread, the total length of piece being about 3½ inches.

Two sets of two bars shall be cast from each heat, one set from the first and the other set from the last iron going into the castings. Where the heat exceeds 20 tons an additional set of two bars shall be cast for each 20 tons or fraction thereof above this amount. In case of a change of mixture during the heat one set of two bars shall also be cast for every mixture other than the regular one. Each set of bars is to go in a single mold. The bars shall not be rumbled or otherwise treated, being simply brushed off before testing.

The transverse test shall be made on all the bars cast with supports 12 inches apart, load applied at the middle, and deflection at rupture noted. One bar of every two of each set made must fulfil the requirements to permit acceptance of the castings represented.

The bars shall be molded two in a flask and cast on end; the bottom of the bar being 1-16 inch smaller in diameter than the top, to allow for draft. Pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled.

The rate of application of the load shall be from 20 to 40 seconds for a deflection of 0.10 inch.

Borings from the broken pieces of the arbitration bar shall be used for the chemical determinations. One determination for each mold shall be required.

For cylinder heads, steam chests and packing rings the silicon must run between 1.60 and 1.80 per cent, the other elements remaining as above. If cylinder castings are to be bushed from the start and also have valve bushings or false valve seats, they should be made of this latter grade of iron.

RECOMMENDATIONS.

At the convention in 1872 the following recommendations were adopted:

"In the matter of cost of keeping up the repairs of engines engaged in switching service exclusively, that an allowance of six miles per hour for the time that such engines are in actual use be allowed:

"That for engines running local freight trains an allowance of six per cent to the train mileage be added for switching:

"That where engines run empty to exceed one-half mile between where the trains are taken or left and the roundhouse, such mileage should be computed, and that for engines running through freight or passenger trains no computation should be made for switching:

SPECIFICATIONS AND TESTS FOR CAST-IRON WHEELS.

At the convention of 1888 the following Specifications and Tests for Cast-iron Wheels were adopted as standard. (See pages 151-154, report 1888.) In 1891 these were changed to Recommendations. (See pages 160, 161, report 1891.)

The specifications and tests are as follows:

Specifications for Cast-iron Wheels.

1. The chills in which the wheels of any one wheelmaker are cast shall be of equal diameters, and the same chill must not vary at different points more than one-sixteenth of an inch in diameter.

2. There shall not be a variation of more than one-half inch in the circumference of any given number of wheels of the same nominal diameter, furnished by any one maker, and the same wheel must not vary more than one-sixteenth of an inch in diameter. The body of the wheel must be smooth and free from slag or blow holes. The tread must be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in the throat which are one-eighth of an inch or over in diameter, or which occur in clusters of more than six inches in length.

3. The wheels broken must show clean, gray iron in the plates; the depth of pure white iron must not exceed seven-eighths of an inch or be less than three-eighths of an inch in middle of the tread, and shall not be less than three-sixteenths of an inch in the throat. The depth of the white iron shall not vary more than one-fourth of an inch around the tread on the rail line in the same wheel.

4. Wheels shall not vary from the specified weight more than two per cent.

5. The flange shall not vary in the same wheel more than three thirty-seconds of an inch from its mean thickness.

6. The single plate part of a 33-inch wheel, known as the Washburn pattern, shall not be less than five-eighths of an inch in thickness in a

wheel weighing from 550 to 575 pounds, and not less than three-fourths of an inch in thickness in a wheel weighing from 575 to 600 pounds.

Tests for Cast-iron Wheels.

1. For each hundred wheels which pass inspection and are ready for shipment, one representative wheel shall be taken at random and subjected to the following test:

The wheel shall be placed flange downward on an anvil block weighing seventeen hundred (1,700) pounds, set on rubble masonry at least two feet deep, and having three supports not more than five inches wide for the wheel to rest upon. It shall be struck centrally on the hub by a weight of one hundred and forty (140) pounds, falling from a height of twelve (12) feet. Should this wheel stand five (5) blows without breaking into two or more pieces, the hundred wheels shall be accepted. Or, wheels must be of such strength that 550 to 575 pound wheels shall require twenty (20) blows, and 575 to 600 pound wheels shall require thirty (30) blows of a hundred (100) pound drop falling seven (7) feet on the plate close to the rim to break a piece out — the wheel resting upon a cast-iron plate weighing not less than one thousand (1,000) pounds.

2. Should in either case the test wheel break into two or more pieces with less than the required number of blows, then a second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test, it shall be optional with the inspector whether he shall test a third wheel or not. If he does not so elect, or if he does and the third wheel stands the test, the hundred wheels shall be accepted.

3. The above tests shall apply to standard weight wheels from 26 inches to 42 inches diameter, used on standard gauge roads.

Form of Contract.

THIS INDENTURE, made this......day of......18.., between.......... party of the first part, and..........party of the second part, WITNESSETH:

1. The party of the first part hereby agrees to furnish to the party of the second part, free on board cars at......chilled cast-iron wheels, ... inches in diameter under the following conditions:

2. The party of the second part hereby agrees to pay to the party of the first part......dollars for each wheel furnished, and to keep an accurate record of the mileage made by the wheels placed in service under cars in passenger equipment and under locomotives and tenders, and an accurate record of the number of months of service of the wheels placed under cars in freight equipment.

3. The party of the second part hereby agrees when any wheel furnished under this contract is scrapped, to furnish to the party of the first part a statement which will show

1.—The wheel number.

2.—The service in which the wheel ran.

3.—The amount of service in months or miles.

4.—The cause of failure.

5.—A charge against the party of the first part of fifty-five per cent (55 per cent) of the price of the wheel mentioned above.

6.—A credit to the party of the first part of

....	cents per 1,000 miles	for	36	in. passenger equipment
....	" "	"	33	" "
....	" "	"	30	" "
....	" "	"	36	in. locomotives and tenders
....	" "	"	33	" "
....	" "	"	30	" "
....	" "	"	28	" "
....	" "	"	26	" "
....	" per month	for	36	in. freight equipment
....	" "	"	33	" "
....	" "	"	30	" "

except in the case of wheels made flat by sliding, or removal for sharp flanges or other unfair treatment, which have not made sufficient service to balance the charge against the party of the first part as above; in such case a service credit shall be made which shall balance the charge.

4. The party of the first part hereby agrees that on presentation of the statement to pay to the party of the second part any balance due from lack of sufficient service on the part of the wheels (with above exceptions) to balance the charge; and the party of the second part hereby agrees to pay to the party of the first part any balance due as shown by the aforesaid statement — settlements to be made quarterly. It is, however, understood and agreed that no credit shall be allowed for excessive mileage for time service on freight wheels beyond the time guaranteed.

5. The party of the second part hereby agrees to hold, subject to the inspection of the party of the first part, for a period of thirty days after the said statement has been rendered, any wheels (with above exceptions) which have not earned for themselves a credit equal to the amount charged against them.

Service Guarantee.

36 inch passenger wheels	70,000 miles
33 " " "	60,000 "
36 inch engine and tender wheels	60,000 "
33 " " "	50,000 "
30 " " "	45,000 "
26 and 28 inch engine and tender wheels	40,000 "
Refrigerator, through line and cattle cars	24 months
All other freight cars	48 "

Settlements of claims for non-performance of guaranteed service shall be made upon the basis of mileage and time guarantee as above.

AIR BRAKE AND SIGNAL INSTRUCTIONS.

At the convention of 1892 a code of Air Brake and Signal Instructions was adopted as Recommendation of the Association. Some modifications were made in 1898, and the modified rules are shown on pages 205-228, report 1898. Revised, June, 1904, as follows :

The title of the revised instructions should be,

"AIR BRAKE AND TRAIN AIR SIGNAL INSTRUCTIONS."

A.—GENERAL INSTRUCTIONS.

1. The following rules and instructions are issued for the government of all employes of this railroad whose duties bring them in contact with the maintenance or operation of the air brake and train air signal. They must be obeyed in all respects, as employes will be held responsible for the observance of same as strictly as for the performance of any other duty.

Every employe whose duties are connected in any way with the operation of the air brake will be examined from time to time as to his qualifications for such duties by the Inspector of Air Brakes or other person appointed by the proper authority, and a record will be kept of such examination.

A book of information will be issued, in convenient form, giving a complete explanation of such parts of the air brake and train air signal equipment as is deemed necessary for the care and operation of same. Any employe of this railroad whose duties require a knowledge of the operation and maintenance of the air brake and air signal will be furnished with a copy of same upon application at place designated by special notice, and every employe will be held responsible for a full knowledge of his duties in the operation or maintenance of the air brake or signal equipment.

B.—INSTRUCTIONS TO ENGINEMEN.

Enginemen when taking charge of locomotives must see that the air brake apparatus on engine and tender is in good working order, and that the air pump and lubricator work properly; that the devices used for regulating main reservoir and train pipe pressures are adjusted at the authorized amount; that brake valve works properly in all its positions; and that, when brakes are fully applied, with cam type of driver brake the pistons do not travel less than 2 inches nor more than 3½ inches, and with other forms from 4 inches to 6 inches, and that the tender brake piston does not travel less than 6 inches nor more than 9 inches. They must know that the air signal responds by opening hose cock on its train pipe.

Enginemen must report to roundhouse foremen, in writing, at the end of the run, any defects in the air brake or train air signal apparatus.

Making up Trains, Testing Brakes at Terminal Points and Before Starting Down Such Grades as May be Designated by Special Instructions.— The train pipe under the tender must always be blown out and maximum pressure obtained in main reservoir before coupling engine to train.

After the train has been charged with air pressure, the engineman shall, at the request of the inspector or trainmen, apply the brakes with full service application and leave them so applied until all brakes operated from the engine have been inspected and the signal given to release. The engineman must then release the brakes and must not leave the station until it has been ascertained that all brakes are released and he has been informed by the inspector, or trainmen, of the number of brakes in service and their condition. In testing passenger brakes, the American Railway Association code of train air signals for applying or releasing must be used, one of which signals must be given from the discharge valve on rear car.

Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with further than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. However, when cars are added to train, the brakes on such cars must be inspected as in terminal test. When a passenger train back-up hose is to be used to control the train, the brakes must be applied for test with the back-up hose, and released from the brake valve on the locomotive.

4. Service Application.— In applying the brakes to steady the train on descending grades, or for reducing speed for any purpose, an initial train pipe reduction of not less than five pounds must be made. Releasing brakes at low speeds must be performed with great care, dependent upon local conditions.

With freight trains, first allow the slack to run up against the locomotive. Great care must then be taken to apply the brakes with five to nine pounds reduction, according to length of train pipe, and not make a second reduction until the effect of the first reduction is felt on entire train, in order to prevent shocks which otherwise might be serious. When a freight train must be brought to a full stop, the train brakes must be held applied until stop is made.

In making a service stop with a passenger train, ALWAYS RELEASE THE BRAKES A SHORT DISTANCE BEFORE COMING TO A DEAD STOP, except on heavy grades, to prevent shocks at the instant of stopping. Even on moderate grades it is best to do this, and then, after release, to apply the brakes lightly, to prevent the train starting, so that when ready to start the release will take place quickly.

5. Emergency Applications.— The emergency application of the brakes must not be used, except in actual emergencies. Under such conditions the brake valve must be left in emergency position until train has come to a full stop.

Engineman's Straight Air Brake Valve on Locomotives.

a — Always keep both brakes cut in and ready for operation, unless failure of some part requires cutting out.

b — Always carry an excess pressure of ten pounds, or more, in the main reservoir, as this is necessary to insure a uniformly satisfactory operation.

c — When using the automatic brake, keep the straight air brake valve in release position; and when using straight air, keep the automatic brake valve in running position; this to avoid driver and tender brakes sticking.

d — The straight air reducing valve should be kept adjusted at forty-five pounds, and the driver and tender brake safety valves at fifty-three pounds.

When a full application of straight air causes either or both safety valves to operate, it indicates that same are out of order, or too high adjustment of the reducing valve or too low adjustment of the safety valve, or leakage of same. Have them tested and adjusted.

6. Brakes Applied from an Unknown Cause.— If it is found that the train is dragging as though the brakes were applied, without rapid falling of the train line pointer, the engineman must make an effort to release the brakes, which may be done as follows: First, if train pipe pressure is less than the authorized amount and the required excess pressure is carried in the main reservoir, move the handle of the brake valve to the full release position for a few seconds and then return it to the running position; secondly, should the train pipe be fully charged with pressure, apply the brakes with a five or ten pounds reduction, according to the length of the train pipe, and release the brakes in the usual manner. In case the brakes can not be released, the train must be stopped and the trainmen notified to examine the brakes.

If, however, the brakes go on suddenly with a fall of the train line pointer, it is evidence that (a) a conductor's valve has been opened, (b) a hose has burst or other serious leak has occurred, or (c) the train has parted. In such an event, the locomotive throttle should be closed and the brake valve handle immediately placed on lap or emergency position, to prevent the escape of air from the main reservoir, and left there until the train has stopped and the brake apparatus has been examined and the signal to release given.

7. Braking by Hand.— Never Use the Air Brake when it is known that the trainmen are operating the brakes of the air brake cars by hand,

except in cases of emergency, as there is danger of injury to the trainmen by so doing.

8. Cutting Out Brakes.— The Driver and Tender Brakes Must Always be Used Automatically at Every Application of the Train Brake, unless defective, except upon such grades as shall be designated by special instructions.

When necessary to cut out either driver or tender brake, on account of defects, it shall be done by turning the handle of the four-way cock in the triple valve down to a position midway between a horizontal and a vertical position, first releasing the brake and leaving the bleed cock open. With the special types of triple valve, close the cut-out cock in the branch pipe.

9. Double Headers.— When two or more locomotives are coupled in the same train, the brakes must be connected through to and operated from the head engine. For this purpose a cock is placed in the train pipe, just below the brake valve. Engineman of each locomotive except the head one must close this cock and carry the handle of brake valve in running position. He will start his air pump and let it run, as though he were going to use the brake, for the purpose of maintaining air pressure on his locomotive and enabling him to assume charge of the train brakes should occasion require it.

10. An Extra Air-Brake Hose, Complete, must always be carried on the locomotive, for repairs in case of burst hose. Upon locomotives having the air signal, a signal hose, complete, must also be carried for the same purpose.

C.— INSTRUCTIONS TO TRAINMEN.

11. Making up Trains and Testing Air Brakes.— When the loco-otive has been coupled to the train, or when two sections have been upled together, the brake and signal couplings must be united, the cocks the train pipes — both brake and signal — must all be open, except ose at the rear end of the last car, which must be closed, and the hose ng up properly in the dummy coupling, when cars are so equipped.

After the train has been charged with air, the engineman must then requested to apply the brakes. When he has done so, the brakes of ch car must be examined to see if they are properly applied. When it is certained that each brake is applied, the engineman must be signaled to lease the brakes. (In testing passenger brakes the American Railway ssociation train air signal whistle code for applying or releasing must used, one of which signals must be given from the discharge valve on e rear car.) The brakes of each car must then be examined to see that ch is released, and the engineman informed as to the number of brakes service and their condition.

If any defect is discovered it must be remedied and the brakes tested gain — the operation being repeated until it is ascertained that every-

thing is right. The conductor and engineman must then be notified that the brakes are all right. Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with other than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. At points where there are no inspectors, trainmen must carry out these instructions. No passenger train must be started out from an inspection point with the brakes upon any car cut out or in a defective condition, without special orders from the proper officers. The air brakes must not be alone relied upon to control any freight train with a smaller proportion of cars with the air brake in service than provided for by special instructions. When hand brakes are also used they must be applied upon those cars next behind the air-braked cars, except in cases of emergency.

12. Detaching Locomotive or Cars.— First close the cocks in the train pipes at the point of separation, and then part the couplings, invariably by hand.

13. Couplings Frozen.— If the couplings are found to be frozen together or covered with an accumulation of ice, the ice must first be removed and then the couplings thawed out by a torch to prevent injury to the gaskets.

14. Brakes Sticking.— If brakes are found sticking, the signal "brakes sticking" must be given as hereafter prescribed by the American Railway Association, or by special rules, in which case, if the brakes can not be released from the locomotive, or if the brakes are applied to detached cars, the release may be effected by opening the bleed cock in the auxiliary reservoir until the air begins to release through the triple valve, when the reservoir cock must immediately be closed.

15. Train Breaking Into Two or More Parts.— First close the cock in the train pipe at the rear of the first section and signal the engineman to release the brakes. Having coupled to the second section, observe the rule for making up trains — first being sure that the cock in the train pipe at the rear of second section has been closed, if the train has broken into more than two sections. When the engineman has released the brakes on the second section, the same method must be employed with refence to the third section, and so on. When the train has been once more entirely united, the brakes must be inspected on each car to see that all are released before proceeding.

16. Cutting Out the Brake on a Car.— If, through any defect of the brake apparatus, it becomes necessary to cut out the brake upon any car, it may be done by closing the cock in the cross-over pipe near the center of the car where the quick-action brake is used, or by turning the handle of the cock in the triple valve to a position midway between a horizontal and a vertical, where the plain automatic brake is used, first releasing the brake. With the special types of triple valves, close the cut-

cock in the branch pipe. When the brake has been thus cut out, the k in the auxiliary reservoir must be opened and left open upon pas-ger cars, or held open until all the air has escaped from the reservoir on freight cars. THE BRAKE MUST NEVER BE CUT OUT UPON ANY CAR ILESS THE APPARATUS IS DEFECTIVE, and when it is necessary to cut out brake the conductor must notify the engineman and also send in a report iting the reason for so doing.

17. CONDUCTOR'S VALVE.— Should it become necessary to apply the akes from the train, it may be done by opening the conductor's valve iced in each car so equipped. THE VALVE MUST BE HELD OPEN UNTIL E TRAIN COMES TO A FULL STOP, AND THEN MUST BE CLOSED AGAIN.

This method of stopping the train must not be used except in case emergency.

18. BURST HOSE.— In the event of the bursting of a brake hose, it ist be replaced and the brakes tested before proceeding, provided the in be in a safe place. If it is not, the train pipe cock immediately in ont of the burst hose must be closed, and the engineman signaled to lease. All the brakes to the rear of the burst hose must then be released hand, and the train must then proceed to a safe place where the burst se must be replaced and the brakes again connected and tested, so as ascertain that the rear brakes are responsive, by test, to the brake valve i engine. One extra air brake hose complete should be carried by all ews and one extra signal hose complete carried by passenger crews for pairs.

19. BRAKES NOT IN USE.— When the air brakes are not in use, either on the road or in switching, the hose must be kept coupled between the rs or hung up properly to the dummy couplings, when cars are so uipped.

20. PRESSURE-RETAINING VALVE.— When this valve is to be used, e trainmen must, at the top of the grade, test the brakes upon the whole ain, and must then pass over the train and turn the handles of the essure-retaining valves horizontally upon all or a part of the cars. as ay be directed. At the foot of the grade, the handles must all be ned downward again. Special instructions will be issued as to the ides upon which these valves are to be used.

21. TRAIN AIR SIGNAL.— In making up trains, all couplings and car charge valves on the cars must be examined to see if they are tight. ould the car discharge valve upon any car be found to be defective, nay be cut out of use upon that car by closing the cock in the branch e leading to the valve. The conductor must always be immediately ified when the signal has been cut out upon any car, and he must ort the same for repairs.

In using the signal, pull directly down upon the cord during one il second for each intended blast of the signal whistle, and allow three conds to elapse between the pulls.

22. REPORTING DEFECTS TO INSPECTORS.— Any defect in either air brake or air signal apparatus discovered must be reported to inspector at the end of the run; or, if the defect be a serious one passenger service, it must be reported to the nearest inspector, anc must be remedied before the car is again placed in service.

D.— INSTRUCTIONS TO ENGINE-HOUSE FOREMEN.

23. GENERAL.— It is the duty of the engine-house foremen to that the air brake and signal equipment is properly inspected upon e locomotive after each run. It must be ascertained that all pipe joi connections and all other parts of the apparatus are air tight, dup gauges tested every thirty days, and that the apparatus is in good work order.

24. AIR PUMP.— The air pump must be tested under pressure, if found to be working imperfectly in any respect, it must be put i thoroughly serviceable condition.

25. PUMP GOVERNOR.— The pump governor should cut off the st supply to the pump when authorized pressure has been obtained.

26. BRAKE VALVE.— This valve must be kept clean and known to in working order in all its positions, before the locomotive leaves engine-house.

27. ADJUSTMENT OF BRAKES.— The driver brakes must be so adjus that the piston travel on the cam type will be not less than 2 inches more than 3½ inches, and in other forms not less than 4 inches nor m than 6 inches. When the cam brake is used care must be taken adjust both cams alike, so that the point of contact of the cams sl be in line with the piston rod. The tender brake must be adjusted means of the dead truck levers, so that the piston travels not less tl six inches when the air brake is applied and the hand brake is releas This adjustment must be made whenever the piston travel is found exceed nine inches.

28. BRAKE CYLINDERS AND TRIPLE VALVES.— These must be examir cleaned and lubricated at least once every six months. A record must kept of the dates of last cleaning and lubrication of these parts for e locomotive.

29. DRAINING.— The main reservoir, and also the drain cup in train pipe under the tender, must be drained of any accumulation af each trip. The auxiliary reservoirs and triple valves must also be drair frequently, and daily in cold weather, and the train pipe under the eng and tender blown out.

30. AIR SIGNAL.— The train air signal apparatus must be examir and tested by suitable appliances from both the head of the engine a the rear of the tender, to know that the whistle responds properly.

pressure gauge must be applied to the air signal pipe once each month, and oftener if found to be necessary, to ascertain that the reducing valve maintains the authorized pressure per square inch in the train signal pipe.

E.—INSTRUCTIONS TO INSPECTORS.

31. GENERAL.—It is the duty of all inspectors to see that the couplings, the pipe joints, the triple valves, the high speed reducing valve, the conductor's valves, the air signal valves, and all other parts of the brake and signal apparatus are in good order, of standard size for the car and free from leaks. For this purpose they must be tested under the full air pressure as used in service. No passenger train must be allowed to leave a terminal station with the brake upon any car cut out, or in a defective condition, without special orders from the proper officer.

If a defect is discovered in the brake apparatus of a freight car, which can not be held long enough to give time to correct such defect, the brake must be cut out and the car properly carded, to call the attention of the next inspector to the repairs required.

Special rules will specify the smallest proportion of freight cars, with the air brakes in good condition, which may be used in operating the train as an air brake train.

32. MAKING UP TRAINS AND TESTING BRAKES.—In making up trains, the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed; the inspector must know that the air is passing through the pipes to the rear end, and the couplings properly hung up to the dummy couplings if so equipped. After the train is fully charged the engineman must be requested to apply the brakes. When the brakes have been applied, they must be examined upon each car to see that they are applied with proper piston travel. This having been ascertained, the inspector must signal the engineman to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) He must then again examine the brakes upon each car to note that all have released. If any defect is discovered, it must be corrected and the testing of the brakes repeated, until they are found to work properly. The inspector must then inform both the engineman and conductor of the number of cars with brakes in good order.

This examination must be repeated if any change is made in the make-up of the train before starting.

HIGH SPEED REDUCING VALVES ON LOCOMOTIVES AND TENDERS must be tested at least once every month, and adjusted to authorized pressure, if necessary, and cleaned and lubricated at least once in three months, and oftner if tests show that same is necessary.

33. Cleaning Cylinders and Triple Valves.— The brake cylinder and triple valves must be kept clean and free from gum. They must b cleaned and lubricated as often as once in six months upon passenger car and once in twelve months upon freight cars. The dates of the las cleaning and lubrication must be marked with white paint on the cylinde or reservoir, in the space left opposite the words:

Cylinder, cleaned and lubricated..............................
Triple, cleaned and lubricated.................................

The triple valves and auxiliary reservoirs must be frequently draine especially in cold weather, by removing the plug in the bottom of th triple valve and opening the bleed cock in the reservoir.

34. Graduating Springs.— The graduating springs in the Westing house quick-action freight triple valves are .049 inch in diameter, nickele steel wire, 16 coils, 2¾ inches free height, 29-64 inch inside diameter, an in passenger .08 inch diameter. nickeled-steel wire, 13¼ coils, 2⅝ inch free height, 29-64 inch inside diameter. The graduating springs use in the Westinghouse plain triple valve in locomotive service are made phosphor-bronze wire, .083 inch in diameter, 12 coils, 2½ inches free heigh 25-64 inch inside diameter.

35. Adjustment of Brakes.— The slack of the brake shoes must b taken up by means of the dead truck levers.

In taking up such slack it must be first ascertained that the han brakes are off, and the slack is all taken out of the upper connection so that the truck levers do not go back within one inch of the truc timber or other stop, when the piston of the brake cylinder is fully bac at the release position. When under a full application the brake pisto travel is found to exceed nine inches upon passenger or freight cars, th brake shoe slack must be taken up and the adjustment so made that th piston shall travel not less than six inches. In taking up the brake sh slack it must never be taken up by hand brakes. Where automatic sla adjusters are applied to any car, such adjuster must be fully releas before the slack is taken up elsewhere.

36. Braking Power.— Where the cylinder lever has more than o hole at the outer end the different holes are for use upon cars of differe weights.

It must be carefully ascertained that the rods are connected to th proper holes, so that the correct braking power shall be exerted upon ea car.

37. Repair Parts.— Inspectors must keep constantly on hand f repairs a supply of all parts of the brake and signal equipment that a liable to get out of order.

38. Hanging Up Hose.— Inspectors must see that, when cars a being switched or standing in the yard, the hose is coupled between th cars or properly secured in the dummy couplings, when cars are s equipped.

39. Responsibility of Inspectors.— Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make any examination of brake apparatus or repairs to the same which they may be called upon to do by trainmen.

GENERAL QUESTIONS REGARDING THE USE OF THE AIR BRAKE AND TRAIN AIR SIGNAL.

GENERAL.

(All parties who have to do with the use, adjustment, care or repairs of air brakes should be thoroughly examined on these questions, in addition to the special questions for each class of men following them.)

1. Question. What is an air brake?

Answer. It is a brake applied by compressed air.

2. Q. How is the air compressed?

A. By an air pump on the locomotive.

3. Q. How does the compressed air apply the brakes?

A. It is admitted into a brake cylinder on each car, and it pushes out a piston in that cylinder, which pulls the brake on.

4. Q. How does the piston get back when the brakes are released?

A. There is a spring around the piston rod which is compressed when the brakes are applied, and when the air is allowed to escape to release the brakes, this spring reacts and pushes the piston in again.

5. Q. Where is the compressed air kept ready for use in the automatic air brake?

A. In the main reservoir on the locomotive, in the smaller or auxiliary reservoir on each car, and in the train pipe.

6. Q. Where does the compressed air come from directly that enters into the brake cylinder when the automatic brake is applied?

A. It comes from the auxiliary reservoir on each car in service application, and from the auxiliary reservoir and train pipe in emergency application.

7. Q. How does it get into the auxiliary reservoir?

A. It is furnished from the main reservoir on the locomotive through the train pipe and triple valve when the brakes are released.

8. Q. How is the automatic brake applied and released?

A. The automatic brake is applied by reducing the air pressure in the train pipe below that in the auxiliary reservoir, and is released by raising the train pipe pressure above that remaining in the auxiliary reservoir.

9. Q. Why does the compressed air not enter directly into the brake cylinder from the train pipe?

A. Because the triple valve used with the automatic brake prevents the air from entering directly from the train pipe to the brake cylinder when the pressure in the train pipe is maintained or increased.

10. Q. What other uses has the triple valve ?

A. It causes the brake cylinder to be opened to the atmosphere under each car, to release the brakes when the pressure in the train pipe is made greater than that in the auxiliary reservoir, and it opens communication from the train pipe to the auxiliary reservoir by the same movement; when the pressure in the train pipe is reduced it closes the openings from the train pipe to the auxiliary reservoir and from the brake cylinder to the atmosphere, and then opens the passage between the auxiliary reservoir and the brake cylinder by the same movement, so as to admit the air and apply the brakes.

11. Q. How many forms of triple valves are there in use, and what are they called?

A. Two; the plain triple and the quick-action triple.

12. Q. How can you tell the plain triple from the quick-action triple?

A. The plain triple has a four-way cock in it, with a handle for operating the cock; the quick-action triple has no such cock in it, but there is a plug cock in the cross-over pipe leading from the train pipe to the triple, when the quick-action triple is used.

13. Q. What are these cocks for in both cases?

A. They are to be used to cut out brakes on one car, without interfering with other brakes on the train, if the brake on that car has become disabled.

14. Q. How does the cock handle stand in the plain triple when the pipe is open for automatic action?

A. It stands in a horizontal position.

15. Q. In what position does the same handle stand when the brakes are cut out by closing the cock?

A. It stands at an inclined position midway between horizontal and vertical.

16. Q. How does the handle in the plug cock in the cross-over pipe, used with the quick action triple, stand for automatic action?

A. It stands with the handle crosswise with the pipe, and groove in plug lengthwise when cock is open.

17. Q. How does the handle and groove stand when the cock is closed and brake cut out of action?

A. It stands with the handle lengthwise of cross-over pipe, and the groove crosswise when closed.

18. Q. How is the train pipe coupled up between the cars?

A. By means of a rubber hose on each end of the train pipe, fitted with a coupling at the loose end.

19. Q. How is the train pipe closed at the rear end of train?

A. By closing the cock in the train pipe at the rear end of last car.

20. Q. How many such train pipe cocks are there to a car, on the air brake train pipe and on the air signal train pipe, and why?

A. Two for each pipe on each car, because either end of any car may sometimes be at the rear end of the train.

21. Q. How many kinds of train pipe cocks are there in use at the ends of the cars?

A. Two.

22. Q. Describe each and give the position of the handle and groove for open and closed in each case.

A. The older form of train pipe cock is a straight plug cock in the train pipe, not far from the hose connection; the handle stands crosswise with the pipe when it is open, and lengthwise with the pipe when closed; it is now found principally on the air signal pipe. The other form of train pipe cock now used on the air brake pipe is an angle cock placed at the end of the train pipe and close to the hose. The handle of the angle cock stands lengthwise with the pipe when open, and crosswise with the pipe when closed. The groove is also a guide to tell whether open or closed.

23. Q. What uses have these train pipe cocks besides to close the pipe at the end of the train?

A. They are used to close the train pipe at both sides of any hose coupling which is to be parted, as when the train is cut in two.

24. Q. Why is it necessary to close the train pipe on both sides of the hose coupling before it is parted?

A. To prevent the escape of air from the train pipe, which would apply the brakes.

25. Q. How must the hose coupling be parted when it is necessary to do so, and why?

A. The air brake must first be released on the train from the locomotive, then the adjacent train pipe cocks must both be closed and the coupling must be parted by hand, to prevent the possibility of injury to the rubber gasket in the coupling.

26. Q. Why must the brakes be fully released before uncoupling the hose between the cars?

A. Because if the brakes are applied upon a detached car they can not be released without bleeding the auxiliary reservoir.

27. Q. In coupling or uncoupling the hose between cars, what must be done if there is ice on the couplings?

A. The ice must first be removed and the couplings thawed out, so as to prevent injury to the rubber gaskets in uncoupling, and to insure tight joints in coupling the hose.

28. Q. What must be done with a hose coupling which is not coupled up, such as the rear hose of a train, or any hose on a car which is standing or running, but not in use?

A. It must be placed in the dummy coupling if provided for in such manner that the flat pad on the dummy will close the opening in the coupling.

29. Q. What pressure should be carried in the train pipe and auxiliary reservoir?

A. The authorized pressure, as per special instructions.

30. Q. Why should the authorized pressure be maintained?

A. Because this pressure is necessary to get the full braking force which each car is capable of using, and, if it be exceeded, there will be danger of sliding the wheels.

31. Q. How much pressure can be obtained in the brake cylinder by the service application of the brakes with seventy pounds in the auxiliary reservoir?

A. About fifty pounds to the square inch, with an 8-inch piston travel.

32. Q. Why can only fifty pounds pressure be obtained under these circumstances?

A. Because the air at seventy pounds pressure in the auxiliary reservoir expands into an additional space when the auxiliary reservoir is opened to the brake cylinder, and when the pressure has become equalized it is thus reduced to fifty pounds.

33. Q. How much must the train pipe pressure be reduced, in order to get fifty pounds pressure in the brake cylinder, in ordinary service?

A. Twenty pounds.

34. Q. Can the brakes be applied so as to get only a portion of this fifty pounds pressure in the brake cylinder, and how?

A. They can be so applied by reducing the train pipe pressure less than twenty pounds.

35. Q. If the train pipe pressure be reduced ten pounds, what will be the pressure in the brake cylinder?

A. About twenty-five pounds.

36. Q. How is this graduated action obtained?

A. By means of the graduating valve in the triple valve.

37. Q. Is it important to keep all the air brake apparatus tight and free from leaks?

A. Yes.

38. Q. Why is this important?

A. In order to get full service from the air brakes, and to prevent the waste of air, and also to prevent the brakes applying automatically by reason of leak in the train pipe.

39. Q. Is it important to know that the train pipe is open throughout the train and closed at the rear end before starting out?

A. Yes, this is very important.

40. Q. Why is this very important?

A. Because if any cock in the train pipe were closed, all the brakes back of the cock which is closed would be prevented from working.

41. Q. How can you ascertain that the train pipe cocks are all open when the train is made up?

A. By testing the brakes; that is, by applying and releasing them, and observing whether they all operate.

42. Q. Do you understand that no excuse will be acceptable for starting out the train without first testing the air brakes?

A. Yes.

43. Q. Why is this rule absolute?

A. Because the safety of passengers and of property depends upon the brakes being properly coupled up and in an operating condition before the train is started.

44. Q. At what other times should the brakes be tested?

A. After each change in the make-up of the train and before starting the train down certain designated grades.

45. Q. From where does the air signal apparatus receive its pressure?

A. From the main air reservoir through the reducing valve.

46. Q. How much air pressure should be carried in the air signal train pipe?

A. The authorized pressure.

47. Q. Is it important that this train pipe and its connections be also kept tight?

A. Yes.

48. Q. After taking up the slack of the brake shoes, how far should the brake piston travel in the cylinders on cars and tenders with a full application of the brake?

A. Not less than six inches, nor more than nine inches.

49. Q. What would happen if the piston traveled less than six inches when brakes are fully applied?

A. A partial application of the brakes might not force the piston beyond the leakage groove in the brake cylinder provided for the escape of small amounts of air.

50. Q. Why should the piston travel not be permitted to exceed nine inches on passenger cars, tenders, or freight cars?

A. Because if it travels farther than this when sent out, a little wear of the brake shoes will cause the piston to travel far enough to rest against the back cylinder head when the brakes are applied, and this cylinder head would then take the pressure instead of its being brought upon the brake shoes.

51. Q. How far should the driver brake piston travel with a full application of the brakes, and why?

A. Not less than two inches nor more than three and one-half inches for the cam type of brake, and from four to six inches for other forms.

52. Q. If the brakes stick upon any car so that the engineman can not release them at any time, how should they be released?

A. By opening the release cock in the auxiliary reservoir and holding it open until air begins to escape from the triple valve, and then closing it again.

53. Q. What is the pressure retaining valve, and what is its use?

A. The pressure retaining valve is a small valve placed at the end of a pipe from the triple valve, through which the exhaust takes place from the brake cylinder. It is used to retard the brake release on heavy grades, and holds the brakes partially applied, so as to allow more time for the engineman to recharge the auxiliary reservoir.

54. Q. What precautions are necessary on every train in regard to hose couplings?

A. Every train must carry at least two extra hose and couplings complete, for use in replacing any hose couplings which may fail or become disabled. These extra hose and couplings to be carried on such part of the train as is required by the rules and regulations.

SPECIAL FOR ENGINEMEN.

55. Q. How should the air pump be started?

A. It should be started slowly, so as to allow the condensation to escape from the steam cylinder and prevent pounding, which is more likely to occur when the air pressure is low.

56. Q. Why should the piston rod on the air pump be kept thoroughly packed?

A. To prevent the waste of air and steam.

57. Q. How should the steam cylinder of the air pump be oiled, and what kind of oil should be used?

A. It should be oiled as little as necessary through a sight-feed lubricator, and cylinder oil should be used.

58. Q. How should the air cylinder of the air pump be oiled; what kind of oil?

A. It should be supplied with valve oil as often as necessary, through a cup provided for that purpose. Also, a well saturated swab should be kept on the piston rod. Lard oil, and other animal or vegetable oils should not be used, as their use causes the brake valve and the triple valves to gum up. The oil must never be introduced through the air inlet ports, as this practice would cause the pump valves to gum up.

59. Q. What regulates the train pipe pressure?

A. The train pipe governor, or feed valve, provided for that purpose.

60. Q. Why should the authorized pressure be carried in train pipe?

A. Because this pressure produces the strongest safe pressure of the brake shoes upon the wheels. A higher train pipe pressure is liable to cause the wheels to slide.

61. Q. What does the feed valve attachment on the brake valve accomplish?

A. When properly adjusted it restricts the train pipe pressure to the authorized amount, with the brake valve handle carried in running position.

62. Q. How often should the brake valve be thoroughly cleaned and oiled?

A. At least once every two months.

63. Q. If the main valve in the brake valve is unseated by dirt or by wear, what may be the result, and what should be done?

A. It may be impossible to get the excess pressure; when the brakes have been applied they may keep applying harder until full on, or when they have been applied they may release. The main valve should be thoroughly cleaned, and if worn it should be faced to a seat.

64. Q. If the piston in the brake valve becomes gummed up or corroded from neglect to clean it, what will be the result?

A. It will be necessary to make a large reduction of pressure through the preliminary exhaust port before the brakes will apply at all, and then the brakes will go on too hard and will have to be released.

65. Q. How and why should the train pipe under the tender always be blown out thoroughly before connecting up to the train?

A. By opening the angle cock at the rear end of the tender and allowing the air from the main reservoir to blow through. This blows out the oil, water, scale, etc., which may accumulate in the pipe, and which would be blown back into the train pipe and triple valves if not removed before coupling to the train.

66. Q. When the locomotive is coupled to the train, why is it necessary to have excess pressure in the main reservoir?

A. So that the brakes will all be released and the train quickly charged when the engineman's valve is placed in the release position.

67. Q. Why should the driver brakes be operated automatically with the train brake?

A. Because it adds greatly to the braking force of the train, and the brakes can be applied alike to all the wheels for ordinary stops, and in an emergency the greatest possible braking force is at once obtained by one movement of the handle.

68. Q. In making a service application of the brakes, how much

reduction of the train pipe pressure from seventy pounds does it require to get the brakes full on?

A. About twenty-five pounds reduction.

69. Q. What should the first reduction be in such an application?

A. Not less than five pounds, so as to insure moving the pistons in the brake cylinders past the leakage grooves.

70. Q. What is the result of making a greater reduction of pressure than twenty-five pounds?

A. A waste of air in the train pipe, without getting any more braking force, and therefore requiring more air to release the brakes.

71. Q. How many applications of the brakes are necessary in making a stop?

A. One or two applications.

72. Q. Why is it dangerous to apply and release the brakes repeatedly in making stops?

A. Because every time the brakes are released the air in the brake cylinders is thrown away, and if it is necessary to apply them again before sufficient time has elapsed to recharge the auxiliary reservoirs the application of the brakes will be weak, and after a few such applications the brakes are almost useless on account of the air having been exhausted from the auxiliary reservoirs.

73. Q. In releasing and recharging the train, how long should the handle of the brake valve be left in the release position?

A. Until the train pipe pressure has risen nearly to authorized pressure.

74. Q. In making service stops with passenger trains, why should you release the brakes just before coming to a full stop?

A. So as to prevent stopping with a lurch; it also requires less time for the full release of the brakes after stopping.

75. Q. In making stops with freight trains, why should the brakes not be released until after the train has come to a full stop?

A. Because long freight trains are apt to be parted by releasing the brakes before rear brakes are fully released.

76. Q. In making service stops, why must the handle of the brake valve not be moved past the position for service applications?

A. So as to prevent unnecessary jerks to the train and the emergency action of the triple valve when not necessary.

77. Q. If you find the train dragging from the failure of the brakes to release, how can you release them?

A. By placing the handle of the brake valve in full release position for a few seconds and returning it to the running position, if the train pipe pressure is not up to the authorized amount; but if maximum pressure is in train pipe, the brakes should be applied with from five to ten pounds

reduction, according to the length of train pipe, and released in the usual manner.

78. Q. When the brakes go on suddenly when not operated by the brake valve, and the gauge pointer falls back, what is the cause, and what should you do?

A. Either a hose has burst, or a conductor's valve has been opened, or the train has parted. In any event, the engine throttle should be closed and the handle of the brake valve should immediately be placed on lap position to prevent escape of air from main reservoir.

79. Q. Are the brakes liable to stick after an emergency application, and why?

A. The brakes are harder to release after an emergency application because they are on with full force and it requires higher pressure than usual in the train pipe to release them again. In this case it is necessary always to have in reserve the excess pressure of the main reservoir to aid in releasing the brakes. With the quick-action triple valve this is especially necessary, because air from the train pipe as well as from the auxiliary reservoir is forced into the brake cylinder when a quick application of the brake is made, thus increasing the pressure in the brake cylinder without the usual reduction of pressure in the auxiliary reservoir, and requiring a correspondingly high pressure in the train pipe afterward to cause the brakes to be released.

80. Q. In using the brakes to steady the train while descending grades, why should the air pump throttle be kept well open?

A. So that the pump may quickly accumulate a full pressure in the main reservoir for use in recharging the train pipe and auxiliary reservoir when the brakes have been released again.

81. Q. In descending a grade, how can you best keep the train under control?

A. First, by commencing the application of the brakes early, so as to prevent too high a speed being reached; secondly, by making an initial reduction that will lightly apply all brakes in the train, and by slowing the train down just before it is necessary to charge the auxiliary reservoir, so as to give time enough to refill same before much speed is again attained.

82. Q. If the train is being drawn by two or more locomotives, upon which locomotives should the brakes be controlled, and what must the engineman of the other locomotive do?

A. The brakes must be controlled by the leading locomotive, and the enginemen of the following locomotives must close the cock in the train pipe just below the brake valves. The latter must always keep the pump running and in order, and main reservoir charged with pressure, with the brake valve in the running position, so that he may quickly operate the brakes if called upon to do so.

83. Q. If the air signal whistle gives only a weak blast, what is t probable cause?

A. Either the reducing valve is out of order so that the pressu is considerably less than forty pounds, or the whistle itself is filled wi dirt or not properly adjusted, or the port under the end of signal valve partly closed by gum or dirt.

84. Q. If the reducing valve for the air signal is allowed to becom clogged up with dirt, what will the result probably be?

A. The signal pipe might get the full main reservoir pressure, ar the whistle will blow when the brakes are released.

85. Q. If you discover any defect in the air brake or signal apparat while on the road, what must be done?

A. If it is something that can not be readily remedied at once, must be reported to the Enginehouse Foreman as soon as the run completed.

86. Q. What is the result if water be allowed to collect in the mai reservoir of the brake apparatus?

A. The room taken up by the water reduces the capacity for holdir air, and the brakes are more liable to stick. In cold weather also tl water may freeze and prevent the brakes from working properly.

SPECIAL FOR ENGINE REPAIRMEN.

87. Q. How often must the air brake and signal apparatus (locomotives be examined?

A. After each trip.

88. Q. Under what pressure must it be examined?

A. Under full pressure.

89. Q. Should the train pipe pressure exceed the maximum, whe would you look for the cause of the trouble?

A. In the devices controlling train pipe pressure.

90. Q. How often must the main reservoir and the drain cup und the tender be drained?

A. After each trip.

91. Q. How often must the triple valves and the cylinders of t driver and tender brakes be cleaned and lubricated?

A. They must be thoroughly cleaned and lubricated once eve six months. If the driver brake cylinders are so located that they becor hot from the boiler, they may acquire lubrication more frequently.

92. Q. If there are any leaks in the pipe joints or anywhere in t apparatus, what must you do?

A. Repair them before the locomotive goes out.

93. Q. How is the brake shoe slack of the cam driver brake taken up, and what precautions are necessary?

A. By means of the cam screws, and it is necessary to lengthen both alike, so that when the brake is applied the point of contact with the cams will be in a line with the piston rod.

94. Q. How is the brake shoe slack of driver brakes on a locomotive with more than two pairs of driving wheels taken up?

A. By means of a turnbuckle or screw in the connecting rods.

95. Q. How is the slack of the tender brake shoes taken up?

A. By means of the dead truck levers; if they will not take it up enough, it must be taken up in the underneath connection, and then adjusted by the dead lever.

96. Q. How far should the driver brake piston travel in applying the brakes?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other forms.

97. Q. What travel of piston should the tender brakes be adjusted for?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other eight inches.

SPECIAL FOR TRAINMEN.

98. Q. How should you proceed to test the air brakes before starting out, after a change in the make-up of a train, or before descending certain specially designated grades?

A. After the train has been fully charged with air, the engineman must be required to apply the brakes; when he has done so the brakes must be examined upon each car to see that the air is applied and that the piston travel is not less than six nor more than nine inches. The engineman must then be required to release the brakes; after he has done so, each brake must be examined again to see that all are released. The engineman and conductor must then be notified that the brakes are all right, if they are found so. (In testing passenger brakes, the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.)

99. Q. In starting out a passenger train from an inspection point, how many cars must have the brakes in service?

A. Every car in the train.

100. Q. When might you cut out a brake upon a passenger car?

A. Never, unless it gets out of order while on the run, in which

case it must be reported to the inspector at the end of the run, or up the first opportunity which may give sufficient time to repair it.

101. Q. If a hose bursts upon the run what must be done, if the train is in a safe place?

A. The hose must first be replaced by a good one, and the engineman then signaled to release the brakes. The train must not proceed until the brakes have been reconnected and tested upon the train to see that all are working properly.

102. Q. If the train is not in a safe place when the hose bursts, what must be done?

A. The train pipe cock immediately ahead of the burst hose must be closed and the engineman signaled to release the brakes. The brakes at the rear of the burst hose must then be released by bleeding the auxiliary reservoirs, and the train must then proceed to a safe place to replace the hose and connect up the brakes, after which the brakes must be tested.

103. Q. If the train breaks in two, what must be done?

A. The cock in the train pipe at the rear end of the first section must be closed and the engineman signaled to release the brakes. The two parts of the train must then be coupled, the hose connected and the brakes again released by the engineman. When it is ascertained that the brakes are all released, the train may proceed.

104. Q. Explain how the pressure-retaining valves are thrown into action or thrown out of action, and when this must be done.

A. The pressure-retaining valve is thrown into action by turning the handle of the valve to a horizontal position, and it is thrown out of action again by placing this handle in a vertical position pointing downward. This handle should be placed in a horizontal position at the top of a heavy grade, and it should always be returned to a vertical position at the foot of the grade, as otherwise the brakes will drag on any cars which still have the handle of the pressure-retaining valve in the horizontal position.

105. Q. If the brake of any car is found to be defective on the run, how should you proceed to cut it out?

A. By closing the cock in the cross-over pipe of the quick-action brake, or in the triple valve of the plain automatic brake, and then opening the release cock in the auxiliary reservoir upon that car, leaving it open, if a passenger car, or holding it open until all the air has escaped from it, if a freight car.

106. Q. When it is necessary to cut out a defective brake upon a car, why should it always be cut out at the triple valve and never by the train-pipe cock at the end of the car, even if it is the last car of the train?

A. The train pipe should always be open from the locomotive to the rear end of the last car, so that if the train breaks in two the brakes will be automatically applied before the parts of the train have separated sufficiently to permit damage to be done by their coming together again,

and so that the brakes may be applied with the conductor's valve upon any car.

107. Q. Should the train pipe burst under any car, what must be done?

A. The train must proceed to the nearest switching point, using the brakes upon the cars ahead of the one with the burst pipe, where the car with the burst pipe must be switched to the rear of the train; the hose must then be coupled up to the rear car and the cock at the rear end of the next to the last car opened, and the cock at the forward end of the last car closed, so that if the train should part between the last two cars the brakes will be applied.

108. Q. What is the conductor's valve, and what is its use?

A. It is a valve at the end of a pipe leading from the train-brake pipe upon each passenger car; it is to be opened from the car in any emergency when it is necessary to stop the train quickly, and only then. When used it should be held open until the train is stopped, and then it should be closed.

109. Q. What is the air signal for, and how is it operated?

A. It is to signal the engineman, in place of the old gong signal, and it is operated by pulling directly downward on the cord for one second and releasing immediately, allowing three full seconds to elapse between pulls.

110. Q. If the discharge valve on the air-signal system is out of order or leaking on any car, how can you cut it out?

A. By closing the cock in the branch pipe leading from the train-signal pipe to the discharge valve; to do so the handle of this cock should be placed lengthwise with the pipe.

111. Q. How is the slack taken up so as to secure the proper adjustment of piston travel?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

SPECIAL FOR INSPECTORS.

112. Q. Do you understand that no passenger train may be started out with any of the brakes cut out of service?

A. I do.

113. Q. Why is it important that no leaks should exist in the air brake service?

A. Because they would interfere with the proper working of the brakes and might cause serious damage.

114. Q. What must be done with the air brake or air-signal couplings when not united to other couplings, on cars equipped with dummy couplings?

A. They must be secured in the dummy coupling, so that the face of the dummy coupling will cover the opening of the hose coupling so as to prevent dust and dirt from entering the hose.

115. Q. If the air issues from the exhaust port of the quick-action triple valve when the brakes are off, what is the cause?

A. It is probably due to dirt on the rubber seated emergency valve.

116. Q. How often must the cylinder and triple valves be examined, cleaned and lubricated?

A. As often as once every six months on passenger cars and once in twelve months on freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinders.

117. Q. What is the difference between the quick-action passenger and freight triple valve?

A. The passenger triple valves have larger ports and slide valves.

118. Q. How may a passenger triple valve be distinguished?

A. By having one exhaust outlet, or suitable lettering designating the class of service.

119. Q. How may a freight triple valve be distinguished?

A. By its two exhaust outlets, one being plugged.

120. Q. When should the graduating spring of the triple valve be replaced with a new one?

A. When it is worn or rusted out, or not of standard size.

121. Q. To what travel of piston must the brakes be adjusted?

A. Not less than six inches, and this adjustment must be made whenever the piston travel is found to exceed nine inches.

122. Q. How is the slack taken up so as to secure this adjustment?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

123. Q. What are the different holes in the outer end of the cylinder levers for, and why must the connections be pinned to the proper hole for each car?

A. These holes are to enable the adjustment of the brake pressure to be made according to the weights of the different cars. The connection must be made to the proper hole in each case, according to the weight of the car, so as to give proper braking power, otherwise the brake will be inefficient, or the wheels may be slid under the cars.

124. Q. How many sizes of high speed brake-reducing valves are there in use, and how will it be known to which size of cylinders they should be connected?

A. There are three sizes, namely, one for 8-inch, one for 10-inch and 12-inch, and a third for 14-inch and 16-inch cylinders, and they can be distinguished by the raised figures cast on their body.

125. Q. To what pressure must the high speed brake-reducing valve be adjusted on passenger equipment cars?

A. The authorized pressure.

CODE OF APPRENTICESHIP RULES.

At the convention of 1898 the following code of rules was adopted as the Recommendation of the Association:

Code of Apprenticeship Rules.

1. A regular apprentice is one who has had no previous shop experience and is not a graduate of a technical institution.

2. No regular apprentice shall be taken into the shop below the age of fifteen or after the age of nineteen years.

3. No apprentice shall be taken into the shop who has not received the elements of a common education, and who does not give evidence of such capacity as to promise the ability to become a competent mechanic.

4. No apprentice shall be taken into the shop without the consent of his parents or lawful guardians, who shall have a thorough understanding of the conditions of such apprenticeship, and who shall execute such documents, including a release of the company from liability for accidents to the said apprentice, as the company may require.

5. The term during which an apprentice shall serve before receiving a certificate of apprenticeship shall not be less than three years, nor more than five years.

6. There shall be a regular apprentice course framed for each shop, which course each apprentice shall go through during his term, the time to be spent on each class of work being defined, and such definition shall be observed as closely as practicable with due regard to the capacities and condition of the individual apprentice.

7. During the term of the apprenticeship a careful and proper record shall be kept of the work and progress of the apprentice, and also of the general behavior and conduct, which record shall be entered on properly authorized blanks or books provided for the purpose not less frequently than once every week during such term.

8. Each apprentice shall be paid for the work done by him upon a scale duly agreed on and provided for in advance.

9. Under no circumstances shall the company assume any liability for the employment of an apprentice after the conclusion of his term.

10. On the conclusion of the term of apprenticeship, each apprentice shall be given a certificate in a proper form, duly signed by the proper officer of the company, which shall set forth the length of time which each apprentice has served and the work on which he has been engaged, as well as some indication of his general behavior during his term.

11. Apprentices who have already served part of a term in other shops, or who have taken part of a course at a recognized technical institution, may be received under such modifications of the foregoing rules as may be deemed proper.

Recommendations Supplementary to the Code of Apprenticeship Rules.

RULE 3. An apprentice should be able to read and write, and have a knowledge of arithmetic. Some companies insist that a candidate shall have reached a point in his studies equivalent to that of the eighth grade of the public schools. This standard, where applicable, will be found satisfactory.

RULE 4. The following is a blank form of release which is recommended as satisfactory:

APPENDIX "C."

(Form for Release of Minors.)

WHEREAS, The A. B. C. Railroad Company has agreed to take into its service .... a minor, subject to discharge at the pleasure of the company, and has agreed with our consent to pay him the compensation to be earned for his services, and has been authorized to take from him such receipts and acquittances as the said company may require;

AND WHEREAS, The said .... by reason of such employment, will be subjected to great risk of personal injury from neglect of other employes, agents and officers of the said company, and from defects of machinery, and from other causes;

AND WHEREAS, In the event of injuries to the said.................. ...., whether resulting fatally or otherwise, the said.. or members of his family might make claims for damages against the said company;

NOW, IN ORDER to release the said company from all claims or liability for damages for injuries of any and all kinds, from any cause whatsoever, ...the father, and ....the mother, in their several and individual capacities, and acting as guardian for the said ...., and the said ....himself, in consideration of the employment by the said railroad company of the said ....in the service of the said company, and in consideration of the sum of one dollar now in hand paid by the said company, do hereby release and forever discharge the A. B. C. Railroad Company for all claims for damages, and do also further agree to release the said company from all claims and liability for damages arising out of any injury or injuries to the said...................... ....resulting from the

character of his employment, from the negligence of other employes, or agents or officers of the said company, from defects of machinery or any other cause or causes whatsoever, whilst a minor and whilst in the service of the said company in any capacity whatsoever.

WITNESS our hands and seals this................day of......18....

	..............................[SEAL]
WITNESSES:	..............................[SEAL]
....	..............................[SEAL]
....	..............................[SEAL]
....	..............................[SEAL]

RULE 5. Four (4) years is recommended as the best standard term. Whenever possible this should be adopted. The limits given in the rule, "not less than three nor more than five years," are made sufficiently wide to cover all special cases. The brightest and most ambitious boy should not be permitted to complete his course in less than three years under any circumstances. A boy who does not complete it in five years had better be something else than a mechanic.

RULE 6. The following courses are recommended for the various shops:

Machine Shop.

TOOL ROOM.— General use of tools, names, etc., work on small planer, drilling machine, shaper and lathes, provide tools; six months to actually serve.

ERECTING SHOP.— Helping on general work — gang No. 1, one month; helping on general work — gang No. 2, one month; helping on general work — gang No. 3, one month.

MACHINE SHOP.— General instructions, milling machine, boring mill, horizontal machine, axle lathe, and helping in general; three months to actually serve.

Boring, driving and truck brasses and quartering machine; two months.

Cylinder boring machine and planer; one month.

Rod: Rod gang, three months; small lathe (alone), two months; large slotter, one month; brass lathe, two months; small planer, one month; large and small planers, two months; driving wheel lathe, one month; large lathe (alone), two months; motion work lathe, one month; general vise work, three months; surface table, three months.

ERECTING SHOP.— General work — gang No. 1, five months; general work — gang No. 2, three months; general work — gang No. 3, four months.

Total number of months' actual service — forty-eight.

Your committee submits this as a basis for an adequate course of training in the machine shop, with the distinct understanding that it is to be qualified so far as the term of service to be spent in the different items, and also in the whole course, by the quality and capacity of the individual boys, under the discretion of whoever has them in charge.

Blacksmith Shop Course.

1. To start the apprentice on a bolt machine for six months. Here he will learn the rudiments of heating iron; also the setting and adjusting of dies, and at the same time by observation will learn the names of the tools and their use in that portion of the shop.

2. The next six months in operating a steam hammer. In this position he has a good opportunity to note how the blacksmiths handle and form iron; at the same time require him to help at the fires in the immediate vicinity of the hammer.

3. The next six months should be as a helper on a small fire, with a man who is quick and handy with light work.

4. The next six months on a light fire without a helper, where he will learn to handle the hand hammer.

5. For the next three months give him a light fire with a helper; the fire should be so located that he will be called upon to assist in taking heats for the larger fires.

6. For the next six months on heavier work that does not require skill.

7. For the next three months put him helping at the tool-dressing fire, and if the shop has two tool-dressing fires, the next three months on the second tool-dressing fire.

8. The next twelve months put him on a heavy fire with as much of a variety of work as can be arranged.

Boiler Shop Course.

1. The first three months heating light rivets.
2. The next three months helping on the heavy sheet-iron work, such as wheel covers, ash pans, etc.
3. Three months holding on rivets for tank work.
4. Three months holding on rivets for boiler work.
5. Six months riveting on patches, chipping and calking on tank work.
6. Six months setting flues.
7. Six months patching and bracing boilers, chipping and calking and general riveting.
8. Six months blacksmithing, to learn how to make and fit braces, to dress necessary tools and assist in fitting up his work.
9. The fourth year to lay out flange and do general boiler work.

Rule 7. It is recommended that some one person be given direct charge of all apprentices and be held responsible for their proper instruction. He can be known as "the Foreman of Apprentices," or he can be designated to perform the duties, without special title, in conjunction with his ordinary work. The following blank page for an Apprentice Record Book is recommended:

APPRENTICE RECORD.

NAME.	WEEKS.																			Total Weeks Worked.	Average Credit, Conduct and Ability.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14 up to 52 weeks							
John Doe....................	80	50	90	70	50	30	90	80	70	50	30	90	80	70	40	70	80	50	30	....	63
James Smith..................	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	....	....
Chas. Jones................ ..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	....	....

RULE 8. The scale of pay must be governed largely by geographical and individual conditions. It is recommended that the rate of pay be 50 cents for a ten-hour day for the first year, with an increase of 25 cents a day for each year thereafter. For an eight-hour day 40 cents a day at the start and 20 cents a day increase yearly.

RULE 9. The following form of certificate is recommended:

APPENDIX "B."

(Form of Certificate of Apprenticeship.)

A. B. C. RAILROAD COMPANY,

MOTIVE POWER DEPARTMENT.

CERTIFICATE OF APPRENTICESHIP.

....
has served an apprenticeship as..
at the shops of this Company at...
during the period from..........................to...................
and has made................hours time over 10 hours per day.

WORK ON WHICH EMPLOYED.

APPROXIMATE NO. OF MONTHS.	KIND OF WORK.
....	....
....	....
....	....

OFFICERS UNDER WHOM EMPLOYED.

NAME.	TITLE.
....	....
....	....
....	....

GENERAL RECORD OF APPRENTICE.

....
....

Supt. Motive Power.

RESOLUTIONS.

Revised and modified at convention, 1903.

At the convention of 1886 the following resolutions prevailed:

Resolved, That this Association deprecates the giving of testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry. (See page 26, report 1886.)

Resolved, That it is the sense of this convention that in practice it is unnecessary to bead flues in the front end. (See page 152, report 1886.)

At the convention of 1888 the following resolution prevailed:

Resolved, That it is the sense of the Master Mechanics' Association that the pilots of all engines should have steps placed on the front end for the safety and convenience of brakemen while coupling at the front ends. (See page 162, report 1888.)

At the convention of 1893 the following resolution prevailed:

Resolved, That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives. (See page 161, report 1893.)

At the convention of 1896 the following resolutions prevailed:

Resolved, That it is the sense of this meeting that the radial stay boiler is as safe as the crown bar boiler, and that the former is easier to keep clean and more economical in repairs. (See page 280, report 1896.)

Resolved, That it is the sense of this Association that the statement of the performance of locomotives should be made on the basis of train load, in lieu of train miles or loaded car miles, as is the prevailing practice at present. (See page 333, report 1896.)

At the convention of 1899 the following resolutions prevailed:

Resolved, That it is the sense of this convention that the time has not arrived when we can abandon instructions to those who use the air brakes, but that the time has arrived when we should perhaps take more care to instruct those who repair the brakes and keep them in order. (See page 71, report 1899.)

Resolved, That it is the sense of the American Railway Master Mechanics' Association that the use of fusible plugs in the crown sheets of locomotive fire boxes is not conducive to the prevention of the overheating of the crown sheet. (See page 153, 1899 report.)

Resolved, That it is the sense of this Association that the ton-mile basis for motive power statistics is the most practical, and encourages economical methods of operating; and that it is desirable that the heads of motive power departments urge its adoption on their managements. (See page 173, report 1899.)

Resolved, That it is the sense of this Association that it is not advisable to use bars in exhaust nozzles. (See page 277, report 1899.)

At the convention of 1901 the following resolutions prevailed:

Resolved, That it is the sense of this Association that a strict comparison of motive power statistics, one road with another, will not secure the best results, but that such comparisons should be made with the records of the same division for preceding periods of time. (See page 79, report 1901.) (See modification, page 70, 1902 report.)

Resolved, That it is the sense of this Association that the ton-mileage of the locomotive is a just credit to the motive power department for statistical purposes. (See page 83, report 1901.) (See modification, page 77, 1902 report.)

Resolved, That it is the sense of this Association that it is necessary that the side rods should be on engines traveling from the works to the railroad they are built for. (See page 99, report 1901.)

At the convention of 1902 the following resolutions prevailed:

"*Resolved,* That it is the sense of this Association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable."

"*Resolved,* That it is the sense of this Association that the ton-mileage of the locomotive and caboose is a just credit to the motive power department for statistical purposes."

"*Resolved,* That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

"*Resolved,* That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

"*Resolved,* That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service to be each further grouped under Through and Local.

"*Resolved,* That the statistics of branch lines and main lines should be kept separately.

"*Resolved,* That the credit of ton-mileage for locomotives in switching service should be proportional to their tractive power.

"*Resolved,* That the ton-mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

"*Resolved,* That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water."

At the convention of 1906 the following motion was adopted:

That twenty-four hours be adopted as the limit distinguishing between engines in service and those under repairs, and that $100 be adopted as the limit distinguishing between running and shop repairs.

Obituary.

CHARLES BLACKWELL.

Charles Blackwell was born at Devizes, Wiltshire, England, on February 4, 1843, and died December 29, 1906. He was the eldest son of Thomas Evans Blackwell, the first vice-president and general manager of the Grand Trunk Railway System, and came to Canada with his father in 1857. Charles Blackwell was descended from a family of engineers, his grandfather, Thomas Blackwell, having built several stone bridges over the River Avon near his native town of Devizes, Wiltshire, and his father, Thomas Evans Blackwell, was the first hydraulic engineer in England, and built the Kennet and Avon Canal. Mr. Blackwell attended the high school and McGill College in Montreal, and in 1860 entered the service of the Grand Trunk Railway and remained with that company until 1869, being employed principally in the motive power department. From 1869 to 1876 he was engaged upon the location and construction of the Intercolonial Railway, three years of this time in charge of a twenty-two-mile section, and two years in charge of a seventy-four-mile section. During this latter period he had supervision of the equipment and the erection of the machinery in the principal repair shops at Moncton, New Brunswick. During 1876 and 1877 he was resident engineer in charge of the completion of forty-five miles of the Quebec, Montreal, Ottawa & Occidental Railway. From 1877 to 1879 he had charge, as resident engineer, of the improvement and construction of the Quebec Central Railway. In 1879 he was appointed mechanical engineer of the Dominion Department of Railways and Canals, and had prepared, under his direction, detail specifications and drawings for the construction of all kinds of rolling stock required for the Canadian Pacific Railway, and also specifications and drawings for the water service on the same road. Upon the completion of construction on the Canadian Pacific Railway in 1881, and the turning over of the line to the operating company, Mr. Blackwell went to Roanoke, Virginia, as superintendent of motive power of the Norfolk & Western and the Shenandoah Valley Railroads. The Roanoke shops were constructed and equipped according to the plans and specifications prepared by him. Mr. Blackwell left the Norfolk & Western Road in 1885 and was engaged for three years on the Union Pacific Railroad, one year of which time he was manager of the Montana Division. In 1888 he went to the Central of Georgia Railway as engineer of the machinery department, and remained with that company at Savannah, Georgia, for two years, but on account of ill health had to come north

again, and from 1891 to 1897 was not engaged in railway work; four years of this time he was with the Schoenberger Steel Company, his headquarters being in Pittsburg. He again entered railroad service at Toledo in 1897 as a special mechanical and civil engineer in the office of the receivers of the Wheeling & Lake Erie Railroad, and remained with this company after the reorganization, and was principal assistant engineer subsequent to August, 1900. During the time that he was engaged on the Wheeling & Lake Erie Railroad he made many investigations and reports on that and other properties. In 1903 Mr. Blackwell was tendered the position of special assistant to the chief engineer of the Wabash Railroad, and entered the service of that company on January 1, 1904, where he remained for two years.

During the last six years of Mr. Blackwell's life the writer of this memoir was fortunate in knowing him intimately, both socially and professionally, and formed a strong attachment for him. Accurate, methodical, resourceful, with a keen mind for detail and a fund of information acquired by long and varied experience as both a mechanical and civil engineer, he was especially well adapted to fill the confidential positions which he occupied during the last eight or ten years of his life.

Loyal, kind and generous, a student of the times, both past and present, he was a charming companion. Born a gentleman, he remained one to the end.

During the last year of his life his health failed rapidly, and he died at Cincinnati on December 29, 1906, of Bright's disease.

On December 27, 1878, Mr. Blackwell married Emily, only daughter of Edward B. Chandler, Esq., Barrister, of The Grange, Moncton, New Brunswick, and granddaughter of the Honorable Edward Barron Chandler, Commissioner of Railways and Governor of the Province of New Brunswick. Mrs. Blackwell and three sons, Thomas Everette, Hubert Charles and John Buckland, survive him.

Charles Blackwell was elected a member of the American Society of Civil Engineers on September 7, 1881. He was also an Associate Member of the Institution of Civil Engineers of Great Britain, an Honorary Member of the American Railway Master Mechanics' Association and a member of the Master Car Builders' Association.

WALTER S. NEWHALL.

ANDREW JACKSON CROMWELL.

Andrew Jackson Cromwell was born in Anne Arundel county, Maryland, June 26, 1831, at a place called Krebs Bridge, near Baltimore city, and died on April 9, 1907, within two months of being seventy-six years old.

His father was Oliver Cromwell, of Baltimore county, an
mother was Helen Warfield, of Anne Arundel county.

After receiving a common-school education he entered the s
of the Granite Company, of Ellicott Mills, Maryland, as machinist ap
tice, this company being engaged in building of cotton mills machine

The firm in question went out of business in 1857 and he
entered the service of the Baltimore & Ohio Railroad Company as ma
ist in the bridge department, and soon became expert in that line an
promoted to erecting foreman, having charge of the erection of seve

the large bridges, namely, the bridge spanning the Cheat River at I
burg, West Virginia, the bridge spanning the Monongahela River at
mont, West Virginia, also the bridge spanning Wheeling cree
Wheeling, West Virginia, leading to the passenger and freight dep
that point.

His native mechanical inclinations not being satisfied in this b
of the service, he asked for a transfer to the locomotive departme
the service, his request being granted, and he entered the Cumbe
(Md.) shops as journeyman machinist in 1854, and finding that his

was congenial he was promoted to gang foreman the same year, and in 1856 was promoted to general foreman of the Cumberland shops.

Thatcher Perkins, who at that time was master of machinery of the Baltimore & Ohio Railroad, promoted him in 1858 to the position of master mechanic in charge of Cumberland Station, where he labored until July, 1865, serving the railroad company in that trying period of the Civil War. Oftentimes it was necessary to run all the locomotives from Cumberland up the line of road to remove them from the invading armies.

In July, 1865, he was promoted to master of mechanics at Piedmont, West Virginia, this being the largest repair shop outside of Mt. Clare on the line of road, being located at the foot of the Allegheny Mountains, the beginning point of the heavy grades on the Baltimore & Ohio system, and at which point a great deal of heavy repairs to rolling stock was done.

In November, 1874, he was transferred to the position of master mechanic at Mt. Clare, Baltimore, headquarters of the company, in which position he served until January, 1881, when he was promoted to the position of assistant master of machinery for the lines east of the Ohio river, and in June, 1884, he was made master of machinery on the lines east of the Ohio river. In 1887 the title was changed to superintendent of motive power, and he held this position till the time of his retirement from active service in June, 1896.

Mr. Cromwell was an untiring worker and a man of strong personalities. The locomotives which he designed and constructed for the Baltimore & Ohio Railroad will leave a record of his natural abilities in this branch of mechanics.

He was for years a member of the Methodist Protestant Church, also a Mason, noted for his integrity and sobriety, and being strictly impartial in his dealings with his subordinate officers and the rank and file of the employees in general, he commanded the respect of all with whom he came in contact.

He is survived by his wife, eight sons and one daughter. His oldest son, Oliver C., is at present mechanical engineer of the Baltimore & Ohio Railroad.

Mr. Cromwell became a member of the American Railway Master Mechanics' Association in 1885, and took an interest in its proceedings until the time of his death, which was caused by infirmities of old age.

E. L. Weisgerber.

THOMAS COYLE.

Mr. Coyle was born at Easton, Pennsylvania, March 14, 1848, and received a common school education. His first employment in the mechanical field was as machinist apprentice at Chester, Pennsylvania, by the

Miller & Allen Manufacturing Co., serving them from January 1, 18 to May 1, 1869, when he resigned. He was then employed as machin at the L. V. R. R. shops at South Easton, Pennsylvania, from May 1869, to March 17, 1870, at which time he was transferred to the Per Amboy shops of the same road as machinist, remaining in this positi until January 1, 1880, when he was promoted to general-foreman, whi capacity he filled until June 1, 1904, when he was transferred to t Weatherly shops of the Lehigh Valley as Master Mechanic, in whi position he was serving at the time of his death, January 10, 1907. M Coyle became a member of this Association in 1905.

G. W. WILDIN.

MICHAEL DUNN.

Michael Dunn was born January 25, 1857, at Lancaster, Pennsylvani and died at Columbus, Ohio, August 14, 1906.

His early education was obtained at the Richmond Business Colleg and immediately after graduating he entered the service of the P. C. St. L. Railway as machinist apprentice at Richmond Shops, Richmon Indiana. After obtaining his trade, and in order to round out his expe rience, he then left the service of the railway company and worked fo the Richmond Machine Works, Robinson Machine Works, C. H. & D. Ry. Co., Pennsylvania Railroad Company at Altoona shop, Baldwin Locomotive Works, Pittsburgh Locomotive Works, and Westinghouse Air Brake Works. He returned to the service of the P. C. C. & St. L. Ry. May, 1890, as roundhouse foreman at Pendleton, Ohio, and was promoted to the position of general foreman of Pendleton shops February, 1891. On January 1, 1894, he received the appointment of road foreman of engines on the Cincinnati Division, and on January 15, 1896, was made master mechanic of Dennison (Ohio) shops. This latter position he held until March 1, 1903, when he was transferred to Columbus shop as master mechanic, and on August 1, 1903, was promoted from this position to the position of superintendent of motive power of South-West System of the Pennsylvania Lines West of Pittsburgh, which position he held until his death.

Mr. Dunn obtained his final position through individual effort and personal merit. He was an able man in his profession and absolutely conscientious in his dealings with men. He had the confidence and coöperation of his subordinates and the respect of his business associates. He was esteemed by all who came in contact with him, and his untimely death, when reaching the summit of his career, is deeply deplored.

T. W. DEMAREST.

J. L. DRISCOLL.

James L. Driscoll was born January 29, 1867, and died January 8, 1906.

He entered the service of the Cincinnati, New Orleans & Texas Pacific Railway as machinist apprentice in 1882 and continued in the employ of said company and the Alabama Great Southern Railroad until the time of his death, with the exception of about three months in the year 1890, when he was employed by the Cincinnati, Hamilton & Dayton Railroad at Lima, Ohio. He served his time as apprentice, worked as machinist until he took service with the Cincinnati, Hamilton & Dayton Railroad as above mentioned, and on his return in September, 1890, was made gang foreman; was appointed general foreman locomotive department at Ludlow in March, 1902; appointed master mechanic Cincinnati, New Orleans & Texas Pacific Railway at Chattanooga, July 14, 1903, was transferred to Alabama Great Southern Railroad as master mechanic at Birmingham January 26, 1904, and returned to the Cincinnati, New Orleans & Texas Pacific Railway as master mechanic at Chattanooga April 9, 1905, he being employed in the latter position at the time of his death, January 8, 1906.

Mr. Driscoll's services with these companies were entirely satisfactory, he being capable and faithful in the discharge of his duties.

J. P. McCuen.

WILLIAM FULLER.

William Fuller was born in Paris, Oxford county, Maine, February 9, 1833; died January 10, 1907, at his home, 2225 East Forty-sixth street, Cleveland, Ohio.

Mr. Fuller entered the railroad service September, 1852, as machinist apprentice and from that time until 1854 was with the Michigan Central Railroad. From 1854 to 1857 he was with the Spartansburg and Union Railroad; from 1857 to 1861 with the Grand Trunk Railroad; from 1861 to 1863 was master mechanic on the Androscoggin Railroad; from 1863 to time of retirement, 1899, was connected with the Atlantic & Great Western Railroad and its successor, the New York, Pennsylvania & Ohio Railroad as superintendent of machinery.

During his time the change of gauge from broad to standard was made. Mr. Fuller created considerable credit in making the change quickly and bringing out what was known as the standard eight-wheel

engine. His record shows him to have followed the line of locomotive engineering from an apprentice machinist to fireman, engineer, master mechanic, and superintendent of machinery, being engaged in this line for fifty-two years, and was considered an expert in locomotive engineering.

After retiring from railroad service he engaged in manufacturing elevator buckets and was so engaged until the time of his death.

He is survived by two daughters, Misses Addie and Edith Fuller, of Cleveland, Ohio.

He became a member of this Association in 1872.

JOHN MACKENZIE.

JOHN O'BRIEN.

Mr. O'Brien was born in Ireland October 15, 1838.

He came to this country at the age of four years, and with his parents made his home, as a boy, at Richmond, Virginia.

After graduating from the schools of Richmond, Virginia, he served his apprenticeship as machinist with the Richmond & Petersburg Railway.

He later took service with the Richmond, Petersburg & Wildon, and later again with the Atlantic Coast Line Railroad. With the latter road he served as locomotive engineer, as master mechanic, for many years at Manchester, Virginia, and of late years as fuel agent for the same road, which position he was filling at the time of his death.

Mr. O'Brien was a public-spirited man, always took an active part in the administration of the affairs of his home city, Manchester, Virginia, where he filled many positions of trust, among which, president of the school board. It is owing to his efforts that there are such splendid schools in Manchester to-day.

He had the full confidence of his employers as well as the public.

To his advice and assistance many of the men now filling responsible positions on railroads in this section of the country owe their successful career; and agree with the poet who said:

"Green be the grass above thee,
Friend of my early days.
None knew thee but to love thee;
None named thee but to praise."

In addition to his widow, Mr. O'Brien leaves two sons and three daughters.

J. F. WALSH.

WILLIAM HENRY LEWIS.

William Henry Lewis, who died at Hoboken, New Jersey, on March 20, 1907, at the age of seventy-nine years, after an illness of a few days' duration, was born in Wales, April 11, 1828.

He received a common school education and started work as an apprentice in the works of the Plymouth Iron Works at the age of sixteen. He came to America in 1848 and secured employment as machinist in the Beaver Meadow Railroad shops at Black Creek, Pennsylvania, and in 1849 worked for a short period in the Reading Railroad shops.

In 1850 he was engaged by the Panama Railroad, which was at that time under construction, as machinist and engineer, remaining in Panama for six months when he was taken ill with "Chagres" fever and was compelled to return home, about the time his engagement with the company expired.

The following year, 1851, Mr. Lewis entered the employ of George Law's Steamship Line, where he remained until the close of 1852.

In May, 1853, he engaged with the firm of Rogers, Ketcham & Groverner, locomotive builders, at Paterson, New Jersey, as machinist and taking out locomotives to different parts of the country. Among these was one built for the Rensselaer & Saratoga Railroad, on which road he remained for one year, having charge of the locomotive for the company.

In 1854 he went with the New York Central and from that road to the Troy & Greenbush road. John Dykeman was at that time Master Mechanic of the Troy & Greenbush, and recommended Mr. Lewis to the Hartford, New Haven & Springfield road, with which road he accepted the position as foreman of the repair shop.

In the fall of 1854 Mr. Dykeman was appointed Master Mechanic of the Greenbush shops of the Hudson River Railroad. He at once installed Mr. Lewis as his foreman, where he remained until 1856, when he became an engineer on that road. During Mr. Lewis' service as engineer, his fireman was the late P. M. Arthur, and between these men there ever remained a feeling of the warmest friendship.

In December, 1871, Mr. Lewis was appointed by President Sloan Master Mechanic of the M. & E. Division of the D. L. & W. R. R., which position he held until 1899, at which time he retired from active service.

Mr. Lewis was noted for his strong personality and was an excellent mechanic.

He became a member of the Master Mechanics' Association in 1873 and was elected an honorary member in 1901. He took an active part in the Association, also in the Railroad Y. M. C. A. He was a generous, warm friend, a member of the different Masonic bodies and a Noble of the Mystic Shrine.

DAVID BROWN.

LOUIS M. KIDD.

Louis M. Kidd was born in Elizabethport, New Jersey, in 1861. He received his education in public school No. 1 and in Dr. Pengris' private school of Elizabethport, New Jersey.

After leaving school at the age of sixteen years he possessed a natural knack for mechanics, and went to work in the Jersey Central shops under Mr. Woodcock, deceased president of the Master Mechanics' Association. After serving his time as apprentice he went to firing on the Jersey Central Railroad and fired about four years. In 1887 Mr. Griggs, who succeeded Mr. Woodcock, sent Mr. Kidd to Mexico to accept a

position as mechanical engineer under Mr. Jennings, who at that time was Superintendent of Motive Power of the Mexican International Railroad. Mr. Kidd ran a locomotive for nine months, and then took charge as mechanical foreman at Monclova.

In 1903 he accepted position with the Coahuila & Pacific Railway, in Saltillo, where he remained until October, 1905, when he returned to his old position in Monclova with the Mexican International Railroad.

In December, 1906, he was transferred to Jaral as mechanical foreman at that point, and was killed by Yardmaster Higgs. He was a man well thought of by both associates and subordinates, and was competent and attentive to his work. His death was regretted by all who knew him.

R. J. SCHMALHAUSEN.

THOMAS DAVIS MacDONALD.

T. D. MacDonald was born at Perth, Canada, September 21, 1854, and died at Iowa Falls, Iowa, May 11, 1906. He entered the service of the Iowa Central Railway as machinist apprentice at the age of sixteen years, and after completion of the trade made the mechanical department of railways his life-work and study, filling various positions of responsibility with credit, and at the time of his death was master mechanic of Des Moines, Iowa Falls & Northern Railway Company.

Mr. MacDonald was a man of sterling qualities, equally respected by all who knew him, and is survived by his wife, daughter and son.

J. E. CHISHOLM.

DAVID O. SHAVER.

Mr. David O. Shaver was born October 17, 1832, at Euphrata, Fulton county, New York. In September, 1848, he entered the machine shop of John Dagget & Son at Newark, New York, as an apprentice, leaving there October, 1851, to accept a position as machinist at Penn Yan, New York. April, 1852, went to Geneva, New York, and in following July entered the service of the Rochester & Syracuse Railroad at Rochester, New York. February, 1853, he went to the New York & Erie Railroad and later to the Michigan Central Railroad, Chicago & Galena Union Railroad, Lake Shore & Michigan Southern Railway and Buffalo & State Line Railroad as machinist, his object in changing his location frequently being to gain a varied experience in railroad work. During this time Mr. Shaver never left a place without giving full notice. March, 1855, he returned to the Lake Shore & Michigan Southern Railway as foreman, and remained until October, 1858, when he resigned to accept a position as General Foreman with the Louisville, New Albany & Chicago Railroad. September, 1861, he accepted the position of Assistant Master Mechanic on the Chioago & Galena Union Railroad, and in August, 1862, was appointed to the position of General Master Mechanic on the Louisville, New Albany & Chicago Railroad. He resigned December, 1864, to accept

position of Master Mechanic with Madison & Indianapolis Railroa remaining until March, 1867, when he resigned to accept the position Master Mechanic, Pittsburgh Division, Pennsylvania Railroad. H became a member of this Association in 1869. He retired from this pos tion September 21, 1900, on account of ill health and died at his residen at East Liberty, Pittsburgh, October 21, 1906.

It is said by all those who knew him best that he was just and uprig in all his dealings with his fellow men, a kind and indulgent husba and father; a true friend, and held in esteem by all with whom he can in contact. His being removed by death was greatly regretted by a ve large circle of friends.

D. F. CRAWFORD.

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